ON THE EFFECT OF ELECTRIC SHOCK ON THE ADRENALS OF THE RABBIT

BY

A. PEKKARINEN, H. HAKALA and K. HYPPÖNEN

It is well known that adrenaline secretion from the adrenals is partly under the control of the central nervous system. Cannon & Rapport (1922) located the reflex centre for adrenaline release near the upper anterior margin of the fourth ventricle and found that it was subject to both excitatory and inhibitory influences. Houssay & Molinelli (1925) and Bender & Weinstein (1942) produced adrenaline secretion by stimulating the hypothalamus. Sugar pique of the floor of the fourth ventricle of the brain raises the blood sugar, but considerably less than if the adrenals or their medullary portion have been removed (Kaiwa & Wada, 1934). Pique increased the adrenaline output in normal animals (Yen, Kaiwa & Wada, 1931). With electric shock, the blood sugar also rises by about 30—40 mg. per cent, and this is considered to be due to the increase in the adrenaline secretion caused by adrenaline (Forsting, Harreveld, Rezwick, Tyler & Wiersma, 1944). The blood sugar is at its maximum in 10 minutes and returns to normal in one hour (Ewald & Haddenbrock, 1942). Repeated shocks give identical results (Serezshkii & Lando, 1946). Electric shock
also raises the lactic acid of the blood two to eight-fold (Se-
rezshkii & Lando, 1946, Ward & Cale, 1944), and immediately
after the shock the cholesterol is also slightly raised (Silfer-
skiöld & Stenberg, 1943). The inorganic phosphorus and potas-
sium of the serum, on the other hand, decrease (Ward & Cale,
1944). The changes observed in the chemistry of the blood are
similar to those found on intravenous administration of adre-
naline (Pekkarinen & Hortling, 1951).

On the other hand, recent investigations have shown that
adrenaline, even in physiological dosage, also controls the
activity of the adrenal cortex through the mediation of the
ACTH of the pituitary body (Long & Fry, 1945, Long, 1946,
Even small doses of adrenaline bring about a clear reduction
in the cholesterol and ascorbic acid of the adrenals. In many
stress reactions too the adrenaline secreted is considered to
bring about the changes in the adrenal cortex characteristic
of the stress reaction. In man in stress ending in death, a cor-
relation has been observed between the ascorbic acid of the
adrenals and adrenaline on the one hand, and between chole-
sterol and adrenaline on the other (Uotila & Pekkarinen,
1951).

It is suggested that electric shock treatment constitutes a
stress for the pituitary-adrenal system. By the simultaneous
administration of cortical hormones, the effect of this stress,
as well as the effect of other stresses on the adrenals, can be
diminished. The latest reports show that electric shock treat-
mment gives better results when adrenal cortical hormones are
given at the same time (Jönsson, Reis & Sahlgren, 1950).

Although the stress reaction has been investigated from
many aspects, it must be noted that the effect of electric shock
treatment on the adrenals has not yet been fully investigated.
In the present study an attempt has been made to demonstrate
in the rabbit the response of both the adrenal medulla and
the cortex to continued electric shock treatment.
### Table 1.
Control group.

<table>
<thead>
<tr>
<th>No.</th>
<th>Body weight gm.</th>
<th>Adrenals Weight mg.</th>
<th>Adrenaline mg.</th>
<th>Adrenaline mg. %</th>
<th>Ascorbic acid mg. mg. %</th>
<th>Cholesterol mg. gm. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂ 1</td>
<td>2640</td>
<td>450</td>
<td>0.18</td>
<td>40</td>
<td>2.0</td>
<td>444</td>
</tr>
<tr>
<td>♂ 2</td>
<td>2110</td>
<td>400</td>
<td>0.16</td>
<td>40</td>
<td>1.0</td>
<td>250</td>
</tr>
<tr>
<td>♂ 3</td>
<td>2070</td>
<td>394</td>
<td>0.22</td>
<td>56</td>
<td>1.1</td>
<td>233</td>
</tr>
<tr>
<td>♂ 4</td>
<td>1300</td>
<td>188</td>
<td>0.27</td>
<td>143</td>
<td>1.4</td>
<td>526</td>
</tr>
<tr>
<td>♀ 5</td>
<td>2800</td>
<td>470</td>
<td>0.43</td>
<td>91</td>
<td>1.0</td>
<td>213</td>
</tr>
<tr>
<td>♀ 6</td>
<td>2220</td>
<td>330</td>
<td>0.22</td>
<td>67</td>
<td>0.4</td>
<td>133</td>
</tr>
<tr>
<td>♂ 7</td>
<td>1920</td>
<td>330</td>
<td>0.17</td>
<td>31</td>
<td>0.3</td>
<td>103</td>
</tr>
<tr>
<td>Mean values</td>
<td>2153</td>
<td>366</td>
<td>0.23</td>
<td>70</td>
<td>0.9</td>
<td>272</td>
</tr>
</tbody>
</table>

### Table 2.
Electric shock group.

<table>
<thead>
<tr>
<th>No.</th>
<th>Body weight mg.</th>
<th>Weight mg.</th>
<th>Adrenaline mg.</th>
<th>Adrenaline mg. %</th>
<th>Ascorbic acid mg. mg. %</th>
<th>Cholesterol mg. gm. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂ 1</td>
<td>1920</td>
<td>385</td>
<td>0.13</td>
<td>34</td>
<td>1.6</td>
<td>403</td>
</tr>
<tr>
<td>♂ 2</td>
<td>1940</td>
<td>605</td>
<td>0.38</td>
<td>63</td>
<td>2.3</td>
<td>380</td>
</tr>
<tr>
<td>♂ 3</td>
<td>2000</td>
<td>342</td>
<td>0.22</td>
<td>64</td>
<td>0.9</td>
<td>257</td>
</tr>
<tr>
<td>♂ 4</td>
<td>2050</td>
<td>286</td>
<td>0.17</td>
<td>59</td>
<td>0.5</td>
<td>164</td>
</tr>
<tr>
<td>♀ 5</td>
<td>2370</td>
<td>810</td>
<td>0.16</td>
<td>20</td>
<td>1.9</td>
<td>234</td>
</tr>
<tr>
<td>♀ 6</td>
<td>2015</td>
<td>430</td>
<td>0.23</td>
<td>53</td>
<td>1.5</td>
<td>349</td>
</tr>
<tr>
<td>♀ 7</td>
<td>2580</td>
<td>1130</td>
<td>0.29</td>
<td>26</td>
<td>1.3</td>
<td>112</td>
</tr>
<tr>
<td>♀ 8</td>
<td>2750</td>
<td>1060</td>
<td>0.27</td>
<td>25</td>
<td>1.1</td>
<td>103</td>
</tr>
<tr>
<td>♀ 9</td>
<td>2350</td>
<td>785</td>
<td>0.22</td>
<td>28</td>
<td>1.4</td>
<td>170</td>
</tr>
<tr>
<td>Mean values</td>
<td>2219</td>
<td>649</td>
<td>0.23</td>
<td>42</td>
<td>1.4</td>
<td>241</td>
</tr>
<tr>
<td>Percentage change</td>
<td>+ 3 %</td>
<td>+ 77 %</td>
<td>-40 %</td>
<td>+ 50 %</td>
<td>-11 %</td>
<td>+ 18 %</td>
</tr>
</tbody>
</table>
MATERIAL AND METHODS

The investigations were carried out on 16 rabbits. In nine of these electric shock was given on 10 successive days (dose $0.1 \times 150$ mV each time), the remaining seven rabbits acting as controls. The shock group consisted of five female and four male rabbits. For the administration of the electric shock, electrodes of a suitable size were placed behind the eye. Since the topographic relations of the skull are not the same in the rabbit as in man, it is not easy to find the same localization for the electrodes as in man. The electrodes have to be placed in the rabbit nearer to the motor area of the brain, which explains the great tendency to convulsions observed in rabbits on the administration of electric shock. The fur was removed at the site of the electrodes and paste was used to increase the conductivity. Each time, definite convulsions lasting for a few seconds were obtained. After this the rabbits were tired for some time, but soon, however, recovered. One day after the termination of the shock treatment, the rabbits were weighed and killed, and their adrenals and some other organs were dissected out and weighed. From the adrenals, adrenaline was determined according to a modification of v. Euler & Hamberg's method (1949), ascorbic acid by Tillman's dichlorphenolindophenol titration, and cholesterol according to Kalaja's method (1939). These methods have been described in a previous paper (Pekkarinen, Hakala, Hyppönen, 1951).

RESULTS

1. In both groups the mean weight of the rabbits was about the same (control group 2153 gm., shock group 2219 gm.).

2. The weight of the adrenals in the control group was 366 mg. In this group not a single clearly enlarged adrenal was found. In the shock group the mean weight of the adrenals was 77 per cent greater than in the control group. In the shock group the adrenals of the females especially were considerably
larger than normal. No pregnancy occurred in the does which could have explained the increase in size of the adrenals. In the shock group the size of the adrenals of the males was clearly increased in only one case. The mean weight of the adrenals per 100 gm. body weight was 17 mg. in the control group and 72 per cent greater in the shock group.

3. The adrenaline content of the adrenals in the control and shock group were about the same, 23 mg., and 0.011 mg. calculated per 100 gm. body weight. The adrenaline concentration in the control group was on an average 70 mg. per cent, and in the shock group 40 per cent smaller.

4. The ascorbic acid content of the adrenals in the control group was on the average 0.9 mg., and 50 per cent greater in the shock group. The concentrations were, however, about the same in both the groups (272 and 241 mg. per cent) as the adrenals of the shock group were relatively larger in size.

5. The cholesterol content of the adrenals in the control group was 10.9 mg. per cent, and in the shock group on an average 18 per cent higher. In view of the larger size of the adrenals in the shock group, the cholesterol concentration of the adrenals of the shock group is 26 per cent lower than in the control group, in which it is 3.1 gm. per cent.

DISCUSSION

When 10 electric shocks are given to nine rabbits on 10 successive days, the following average changes are observed in the adrenals: the weight of the adrenals increases by 77 per cent (calculated per 100 gm. body weight, by 72 per cent), their adrenaline concentration decreases on the average by 40 per cent, the ascorbic acid concentration is about the same in both groups (in the shock group 11 per cent lower) and the cholesterol concentration decreases on the average by 26 per cent. A striking observation is the fact that all the adrenals have not responded in the same way, but that the four adrenals of female experimental animals reacted more markedly
to the shock treatment than did the others: their weight increased by 132 per cent, the adrenaline concentration decreased by 64 per cent, the ascorbic acid concentration decreased by 38 per cent and the cholesterol concentration decreased by 52 per cent. On calculating the means of the size, it is found that in those adrenals in which the size has not so clearly changed, the concentrations of these substances too have not so clearly decreased as in the former adrenals: the weight has only decreased by 11 per cent, the adrenaline concentration has decreased by 21 per cent, the ascorbic acid concentration has increased by 7 per cent, and the cholesterol concentration has remained on the average unchanged. In the cases investigated, shock treatment has thus been observed to have a different effect on the adrenals of the rabbit in different cases. To what extent the results obtained in these experiments can be generalized to apply to those changes caused by electric shock treatment in human adrenals, is difficult to say on the basis of this investigation. It is, however, probable that electric shock treatment also causes similar changes in human adrenals. Further investigation is still required to solve the question of whether cortical hormone treatment is needed particularly in those cases in which the adrenals have not reacted to the electric shock treatment, or whether vice versa cortical hormone treatment is needed to prevent the grosser changes caused by electric shock treatment in the adrenals.

SUMMARY

1. An electric shock was given to nine rabbits on 10 successive days. An investigation has been made of the changes in the adrenals brought about by electric shock treatment. The material has been compared with seven controls.

2. The size of the adrenals in the shock group was increased on the average by 77 per cent, adrenaline concentration decreased by 40 per cent, ascorbic acid concentration remained
approximately unchanged, and cholesterol concentration decreased by 26 per cent.

3. In some of the adrenals of the shock group, especially in four female adrenals, considerably more marked changes were observed than in the others. Their weight increased on the average by 132 per cent, the adrenaline concentration decreased by 64 per cent, ascorbic acid concentration decreased by 38 per cent and the cholesterol concentration decreased by 52 per cent.

4. In the other five adrenals of the shock group the changes are very slight: the weight increased on the average by 11 per cent, adrenaline concentration decreased by 21 per cent, ascorbic acid concentration increased by 7 per cent, and the cholesterol concentration remained on the average unchanged.

REFERENCES