CORTICAL AND MEDULLARY ADRENAL ACTIVITY
IN EMOTIONAL STRESS

By

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and Gunnar Ström

Adrenocortical activation, as reflected by a rise in the plasma level of 17-hydroxycorticosteroids, occurs before a surgical operation (Franksson & Gemzell, 1955) and during situations of emotional disturbance (Bliss et al., 1956). The plasma level of 17-hydroxycorticosteroids after delivery is higher in primiparae than multiparae (Gemzell, 1954), an observation which also suggests that psychological stress which is more intensively felt by a woman in her first than her subsequent deliveries, may activate the adrenal cortex.

Adrenomedullary activation by emotional stimuli was demonstrated in animals in the classical experiments of Cannon (1929, 1931) and his co-workers. More recently Euler & Lundberg (1954) showed that emotional stress associated with air transportation was accompanied by a selective increase in the urinary excretion of adrenaline. In extensive experiments Elmadjian et al. (1958) have studied the catecholamine excretion in various kinds of stress and found increased excretion of adrenaline as well as noradrenaline depending on the situation.

The present study was designed to investigate further the influence of emotional stress in human subjects on cortical and medullary adrenal function, using selected moving pictures as emotional stimuli.

The activity of the adrenal cortex and medulla was estimated by determinations of the plasma level of 17-hydroxycorticosteroids and the urinary excretion rates of 17-ketosteroids, corticosteroids, pregnanediol, adrenaline and nor-

1. Supported by a grant from Konung Gustaf V:s 80-års fond.
adrenaline. The ten subjects were male medical students who were considered relatively homogeneous from a social and cultural point of view. All the students were known to be healthy without any endocrine or psychological abnormalities. Age ranged between 23 and 31 years.

PROCEDURE

The stress situation consisted of the presentation of 30 cuttings from fiction and documentary moving pictures, showing a selected variety of murders, fights, torture, executions and cruelty to animals. All the cuttings were of such a kind that they had been disapproved of by the Swedish Board of Film Censors for public exhibition. The total length of the films was 1,800 m. and they lasted for about one hour. The showing was divided into two half-hour sessions with a short intermission for examinations.

The experiment started about 6 p.m. The subjects had been instructed to empty their bladders and to take a glass of water two hours before the showing. They also had been instructed to avoid all kind of exertion during the day of the experiment. Urine samples were collected in two 2-hour periods, one preceding the experiment (control period) and one including the entire showing (experimental period). A second glass of water was taken immediately before the experiment. Venous blood samples were drawn and blood pressures and pulse rates recorded in the sitting position immediately before the showing, during the intermission and at the end of the experiment. The subjects sat down during the whole experiment.

After the showing, a questionnaire of fourteen questions was handed to each of the participants. The questions were designed to elucidate the individual reaction to this special showing as well as to the motion pictures in general.

Due to the psychological complexity of the stress situation with each separate cutting having a special emotional value for each subjects, a complete personality rating of the subjects was not judged to be of particular interest and was therefore not carried out.

METHODS

The concentration of 17-hydroxycorticosteroids in the plasma was determined by the method of Nelson & Samuels (1952). The urinary excretion of 17-ketosteroids was determined by the method of Callow et al. (1938) with the modification of Vestergaard (1951). The amount of corticosteroids in the urine was estimated as 17-ketogenic steroids by the method of Norymberski (1952) with the modification of Diczfalussy et al. (1955) and the urinary pregnanediol was determined according to the method of Klopper et al. (1955). Adrenaline and noradrenaline in urine were prepared and estimated by the method of Euler & Orwén (1955).

The average normal level of 17-hydroxycorticosteroids in the plasma at 8 a.m., based upon determinations in 52 normal subjects, is 11.5 ± 1.0 μg. per 100 ml. of plasma (Gemzell et al., 1955). The normal diurnal rhythm is characterized by a maximum in the early morning and a drop to a lower level during the rest of the day (Gemzell et al., 1953, Bliss et al., 1953). According to Hamburger (1948) the urinary excretion of 17-ketosteroids in normal men, 25 years of age, is on an average 15 mg. per 24 hours or 10.5 μg. per minute. The urinary excretion of corticosteroids is according to Diczfalussy et al. (1955) on an average 10.6 mg. per 24 hours or 7.4 μg.
per minute. In men the average excretion of pregnanediol is 0.92 mg. per 24 hours (Klopper et al., 1955) or 0.64 μg. per minute.

The average normal excretion of free adrenaline and noradrenaline is 3.4 μg. and 23 μg. per minute, respectively, during the day according to Euler et al. (1955).

It has been shown (Migeon et al., 1956) that the excretion rate of urinary corticosteroids has a diurnal variation similar to that of the plasma level of 17-hydroxycorticosteroids. Whether the other urinary steroids investigated in this study also show a diurnal variation is at present not known. However, the experimental results of this study should in the first place be compared with the data obtained for the plasma and urine of the control period.

Arterial blood pressure was measured by the conventional cuff method, the diastolic pressure being read at the disappearance of the Korotkow sounds.

RESULTS

Plasma level of 17-hydroxycorticosteroids. The average concentration of 17-hydroxycorticosteroids at 6 p.m. (Table 1) was 8.4 μg. per 100 ml. plasma, a value which seems to fall within the normal range when the diurnal variation is considered. In the intermission and after the completion of the experiment, the average concentration was slightly lower, 26 and 6 per cent respectively, but the decrease was not statistically significant.

Rate of urinary excretion of 17-ketosteroids, corticosteroids and pregnanediol. The average urine volume per two hours (Table 1) increased from 152 ml. during the control period to 285 ml., i.e. by 88 per cent, during the experimental period (difference not significant, P = 0.08). The average urinary excretion rates of 17-ketosteroids, corticosteroids and pregnanediol increased by 33 per cent (probably significant change, P = 0.05), 16 per cent (not significant, P = 0.2) and 39 per cent (probably significant change, P = 0.04), respectively.

Rate of urinary excretion of catechols. Compared with the control period, the excretion rate of adrenaline and noradrenaline (Table 1) increased during the experimental period by 70 per cent (significant change, P = 0.007) and 35 per cent (probably significant change, P = 0.04). If calculated on the basis of individual differences the changes were similar (adrenaline, 0.01 > P > 0.001; noradrenaline 0.05 > P > 0.02), respectively.

Blood pressure and pulse rate. The average systolic pressure (Table 2) decreased significantly during the experiment from 135 to 115 mm. Hg (P = 0.001), and the average diastolic pressure showed a probably significant decrease from 82 to 75 mm. Hg (P = 0.04). The pulse rate also decreased significantly, from 79.4 to 72.5 (P = 0.006) beats per minute.

Individual emotional reaction. Eight of the ten students reacted to the total performance with discomfort, one was emotionally indifferent (no. 10) and one experienced pronounced discomfort (no. 2). Subjects nos. 2, 5, 6 and 8 declared that they occasionally dreamed about motion pictures they had attended and that they often wept when looking at tragic films.
Table 1.

Plasma levels of 17-hydroxycorticosteroids, urine volume and urinary excretion rate of 17-ketosteroids, 17-ketogenic steroids, pregnanediol, adrenaline and noradrenaline during the control and the experimental periods.

<table>
<thead>
<tr>
<th>Subject no.</th>
<th>Plasma, pre-exp. 17-OHCS</th>
<th>Urine, control period (2 hrs.)</th>
<th>Plasma, intermission 17-OHCS</th>
<th>Urine, experimental period (2 hrs.)</th>
<th>Plasma, post-exp. 17-OHCS</th>
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<tbody>
<tr>
<td></td>
<td>μg.</td>
<td>ml.</td>
<td>μg./min.</td>
<td>μg./min.</td>
<td>μg.</td>
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<tr>
<td>1</td>
<td>2.0</td>
<td>75</td>
<td>8.3</td>
<td>17.5</td>
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<tr>
<td>2</td>
<td>2.0</td>
<td>42</td>
<td>9.2</td>
<td>10.0</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>5.9</td>
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<td>12.5</td>
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<tr>
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<td>5</td>
<td>22.8</td>
<td>70</td>
<td>6.7</td>
<td>7.5</td>
<td>1.2</td>
</tr>
<tr>
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<td>8.3</td>
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<tr>
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<tr>
<td>10</td>
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<td>190</td>
<td>14.2</td>
<td>12.5</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Mean 8.4 | 152 | 11.7 | 12.3 | 1.0 | 6.9 | 15.4 | 6.2 | 285 | 15.3 | 14.7 | 1.4 | 11.7 | 20.8 | 7.9 |
**Table 2.**

Pulse rate and arterial blood pressure before, during and after the experiment.

<table>
<thead>
<tr>
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<th>Preexperimental</th>
<th>Intermission</th>
<th>Postexperimental</th>
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<tr>
<td><strong>No. of subjects</strong></td>
<td>10</td>
<td>10</td>
<td>10</td>
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<tr>
<td><strong>Pulse rate</strong></td>
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<tr>
<td>(beats per min.)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>mean value</td>
<td>79.4</td>
<td>75.9</td>
<td>72.5</td>
</tr>
<tr>
<td>range</td>
<td>69–96</td>
<td>61–92</td>
<td>62–86</td>
</tr>
<tr>
<td><strong>Arterial blood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pressure (mm. Hg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean value</td>
<td>138/82</td>
<td>125/79</td>
<td>115/75</td>
</tr>
<tr>
<td>range</td>
<td>115–150/75–95</td>
<td>110–150/70–95</td>
<td>105–130/60–90</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The present experiment was primarily intended to show whether strong emotional stimuli of relatively short duration could provoke significant endocrine reactions. It appeared from the answers in the questionnaires, however, that the emotional stress experienced by the subjects during the showing was not particularly strong. Only one subject noted pronounced discomfort, and three others declared that although they occasionally felt pronounced discomfort when seeing moving pictures of this kind they only experienced moderate discomfort on the present occasion. The result, therefore, probably expressed the reaction to moderate emotional stimuli of relatively short duration. As judged by the plasma levels of 17-hydroxycorticosteroids before, during and after the experiment, the films should not have had any effect on the adrenal cortex. The plasma level decreased slightly during these two hours, as it probably would have done in any case due to the normal diurnal variation. The urinary excretion rates of 17-ketosteroids and pregnanediol, on the other hand, showed a slight increase during the experiment, which suggests that during the showing the adrenal cortex had been activated even if the activation had subsided at the end of the experiment.

The urinary excretion rate of adrenaline and possibly also of noradrenaline was increased during the experimental period. The more pronounced influence on the adrenaline secretion is in agreement with previous observations of Euler & Lundberg (1954) and Elmadjian et al. (1958). It should also be noted that the adrenaline figures were increased when compared with the normal values
given by Euler et al. (1955) while the noradrenaline figures were not increased. As both pulse rate and arterial blood pressure were found to be lower at the intermission and at the end than at the start, it is probable that any general sympathetic activation which may have been present quickly disappeared when the film showing ended.

When the measurements of hormones in the blood and urine are correlated with the emotional reaction of the individual subject, it is found that subject no. 2, the only one indicating pronounced discomfort, showed the most significant endocrine reaction. This subject as well as nos. 5, 6 and 8, differed from the others by being disposed to become absorbed by motion pictures in general. As shown in Table 1, these four subjects showed a more pronounced endocrine reaction than the others.

The results of this study therefore indicate that emotional stress of a moderate degree and of relatively short duration is able to provoke a measurable reaction of the adrenal medulla. This is in good agreement with the previous findings in animals, made by Cannon (1929), and in man by later investigators. As a moderate increase in the urinary excretion rate of the cortical steroids occurred, it seems probable that a reaction of the adrenal cortex also took place. This tentative conclusion is made more probable by the individual correlation which seemed to exist between the subjective emotional reaction and the objective endocrine reaction.

**SUMMARY**

Cuttings from fiction and documentary moving pictures, showing a selected variety of murders, fights, torture, executions and cruelty to animals, were shown during one hour to 10 normal subjects (medical students). During the showing the urinary excretion rates of 17-ketosteroids, pregnanediol and noradrenaline showed a slight increase and that of adrenaline a more pronounced increase. At a short intermission and immediately after the end of the experiment both arterial blood pressure and pulse rate were lower than just before the start.

Eight of the subjects reacted emotionally to the cuttings by discomfort, one by pronounced discomfort and one was indifferent. They judged the discomfort as corresponding to only a slight or moderate emotional reaction.

The results give further indication that moderate emotional stress of relatively short duration may activate both the adrenal medulla and the adrenal cortex.

**ACKNOWLEDGMENT**

The authors are greatly indebted to Dr. E. Diczfalusy, Stockholm, for the determinations of the urinary 17-ketosteroids and 17-ketogenic steroids.
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