The effect of mental stress on catecholamines, their metabolites and plasma renin activity in patients with essential hypertension and in healthy subjects

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Summary

1. Ten patients with essential hypertension and ten healthy men were submitted to mental stress consisting of Kraepelin’s arithmetic test combined with noise. Concentrations of plasma and urine catecholamines and of their metabolites as well as plasma renin activity before and after the test were studied.

2. In both groups a significant increase of noradrenaline and adrenaline in blood and noradrenaline in urine was observed. The urinary excretion of dopamine fell significantly in both groups after stress.

3. After mental stress a significant increase in urinary excretion of 3-methoxy-4-hydroxyphenylglycol was observed in both groups. The excretion of vanillylmandelic acid decreased significantly only in healthy subjects.

4. The plasma renin activity rose significantly in both groups but the increase was more pronounced in healthy subjects.

Key words: catecholamines, catecholamine metabolites, mental stress, plasma renin activity.

Introduction

Recently much attention has been paid to the role of the central nervous system in the pathogenesis of essential hypertension. In spite of substantial progress in this field the significance of psychological stress in the development of essential hypertension is not fully understood.

It is known that the central nervous system influences peripheral sympathetic activity, as well as the renin–angiotensin system, which plays an important role in the physiological regulation of blood pressure. For that reason the influence of mental stress on catecholamines, their metabolites and plasma renin activity was investigated.

Methods

Ten male patients with essential hypertension, aged 18–42 years (mean age 26.9), and ten healthy men aged 26–43 years (mean age 32.9) were studied. All subjects were hospitalized and remained on a standard hospital diet with normal sodium intake. The patients did not receive any medication for at least 2 weeks before the study.

On the day of the investigation the subjects remained in a quiet room and 30 ml of venous blood was withdrawn through an indwelling catheter after 3 h of rest in the sitting position, during which time the urine was collected. Three measurements of blood pressure were then taken with an Arteriosonde (Roche) and simultaneously the pulse rate was measured.

The subjects performed a simple mental task (Kraepelin’s arithmetic test, which consists of summing columns of four two-digit figures) under continuous noise delivered through the earphones for 30 min. The noise itself consisted of the specially prepared tape recording of the superimposed sounds of urban traffic, unintelligible bits of speech and occasional bursts of noise produced by heavy machinery. These sounds have been selected as an analogue of the spectrum of complex noises present in the urban environment. The tape
was played at about 90 dBA. Subjects were studied individually.

After the test the measurements of blood pressure and pulse rate were repeated and a sample of venous blood was taken again. The subjects then collected the urine for another 3 h.

The following methods were used for the determination of catecholamines and their metabolites: for noradrenaline and adrenaline the method of Anton & Sayre (1964), for dopamine the method of Carlsson & Waldeck (1958), for vanillylmandelic acid the method of Pisano, Crout & Abraham (1962) and for 3-methoxy-4-hydroxyphenylglycol the method of Antun, Pullar & Eccleston (1971). Plasma renin activity was measured by radio-immunoassay (CEA-IRE-Sorin kits). Student's t-test was used for statistical analysis.

**Results**

The results are summarized in Table 1. In both groups mental stress produced significant increase of noradrenaline and adrenaline in blood and noradrenaline in urine. There was no statistically significant difference between hypertensive and healthy subjects in relation to the above-mentioned changes. The urinary excretion of adrenaline did not increase in any of the investigated groups. The urinary excretion of dopamine fell significantly in both groups after mental stress and the excretion of vanillylmandelic acid decreased only in healthy subjects. The most pronounced change in metabolite excretion in response to mental stress was a significant increase of 3-methoxy-4-hydroxyphenylglycol in both groups. The plasma renin activity after stress rose significantly both in hypertensive and in control subjects, but the increase was more pronounced in healthy subjects. The absolute values as well as the increments of plasma renin activity after stress were significantly lower in patients with hypertension than in healthy subjects.

**Discussion**

It is believed that psychological factors may play a substantial role in the development of essential hypertension (Jonsson & Hansson, 1977; Mustacchi, 1977; Nestel, 1969). The effect of mental stress could be related to the activation of the sympatho–adrenal system. As could be expected, in this work we found distinct changes in catecholamines and their metabolites in response to mental stress. It should be underlined that the most pronounced change was an over twofold increase of 3-methyl-4-hydroxyphenylglycol in urine in both groups, which may be an indirect indication of augmented metabolism of noradrenaline in the central nervous system (Maas & Landis, 1968). The higher excretion of 3-methyl-4-hydroxyphenylglycol and lower excretion of vanillylmandelic acid after mental stress may reflect the augmented metabolism of catecholamines through increased activity of aldehyde dehydrogenase.

Another interesting finding was the diminished urinary excretion of dopamine in both groups, which could be related to the increased synthesis of noradrenaline. However, the enhanced metabolism of this amine could not be excluded.

**Table 1. Plasma concentrations of catecholamines, of their metabolites and plasma renin activity before and after mental stress in hypertensive and healthy subjects**

VMA, Vanillylmandelic acid; MHPG, 3-methoxy-4-hydroxyphenylglycol. *Statistically significant difference between patients and controls (P < 0.05). N.S., Not significant.

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<thead>
<tr>
<th></th>
<th>Hypertensive (n = 10)</th>
<th>Control (n = 10)</th>
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<tr>
<td></td>
<td>Before test</td>
<td>After test</td>
</tr>
<tr>
<td>Blood</td>
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<tr>
<td>Noradrenaline (μg/l)</td>
<td>0.62 ± 0.08</td>
<td>0.81 ± 0.11</td>
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<tr>
<td>Adrenaline (μg/l)</td>
<td>0.25 ± 0.03</td>
<td>0.36 ± 0.06</td>
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<tr>
<td>Plasma renin activity (ng h⁻¹ ml⁻¹)</td>
<td>2.52 ± 0.31</td>
<td>2.88* ± 0.28</td>
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<tr>
<td>Urine</td>
<td></td>
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<tr>
<td>Noradrenaline (μg/3h)</td>
<td>3.06 ± 0.50</td>
<td>4.74 ± 0.57</td>
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<tr>
<td>Adrenaline (μg/3h)</td>
<td>1.11 ± 0.22</td>
<td>1.02 ± 0.23</td>
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<tr>
<td>Dopamine (μg/3h)</td>
<td>34.12* ± 2.82</td>
<td>24.02 ± 2.49</td>
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<tr>
<td>VMA (mg/3h)</td>
<td>1.52 ± 0.13</td>
<td>1.64 ± 0.36</td>
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<tr>
<td>MHPG (μg/3h)</td>
<td>31.61 ± 5.67</td>
<td>71.91 ± 7.26</td>
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It should be pointed out that there were no substantial differences in the response of catecholamines and their metabolites to stress between hypertensive and normotensive subjects. However, it does not exclude the possibility that mental stress may contribute to the development of hypertension. In view of the complexity of the relationship between the central nervous system and hypertension the effects of stress may depend on the character of psychological stimuli, duration of their action and individual response of the subject (Peters, 1977).

In the light of the close relationship between sympathetic activity and the renin–angiotensin system the changes of plasma renin activity after stress deserve special attention. The activity rose in both investigated groups but its rise was much less pronounced in patients with hypertension than in healthy subjects. It may indicate diminished reactivity of the juxtaglomerular apparatus to the sympathetic stimuli in patients with hypertension under the influence of stress.

The results obtained in this work do not allow definite conclusions to be drawn concerning the mechanism of the observed changes and their significance for the pathogenesis of essential hypertension. For this purpose further studies are needed on a larger series of patients and with different kinds of psychological stress.

References


