Cognitive Processes in Hypertension

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SUMMARY In 15 normotensive subjects, 17 newly diagnosed, untreated hypertensive patients, and 22 effectively treated hypertensive patients, a battery of neuropsychological tests was given. All subjects were neurologically asymptomatic. The neuropsychological battery included tests evaluating global cognitive functions (Card Sorting Test, Wechsler Memory Scale, Progressive Matrices 1938), as well as specific cognitive functions (Benton Test, subtests of the Wechsler-Bellevue Scale). Normotensive controls obtained better scores in all the tests. Statistical analysis of the scores suggests that hypertension is highly correlated with impairment of memory, logical reasoning, visuospatial organization, and attention. Therapy seems to impair attention, while the duration of disease seems to influence visuospatial performances.

(Hypertension 4: 226-229, 1982)

KEY WORDS • hypertension • cognitive functions • neuropsychological tests

RECENT years have brought to light increasing evidence of the fundamental role played by arterial hypertension in the pathogenesis of stroke. In a high percentage of hypertensive patients deceased without neurological complications, mild but diffuse cerebrovascular abnormalities have been found. In spite of such frequent cerebral damage, neurological symptoms and signs seem to be rare and mild in hypertensive patients. In our experience, hypertensive patients often report slightly impaired powers of concentration, lightheadedness, and easy fatigue, causing impaired intellectual performance. These symptoms might correlate with diffuse and mild cerebrovascular abnormalities, but might also be explained by neurophysiological cortical depression, clearly shown in experimental models, or by emotional reactions to the illness.

Personality and psychological factors predisposing to, sustaining, and determined by hypertension have been extensively investigated. These investigations, although interesting for a global approach to hypertensive patients, are beyond the aim of our study, which is to investigate the possible neuropsychological deficits induced by neurologically asymptomatic hypertension.

For this purpose we compared the results obtained by normotensive and hypertensive subjects in a battery of widely used neuropsychological tests.

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Methods

Subjects

The subjects were divided in three groups: Group A (15 normotensive subjects), Group B (17 newly-diagnosed untreated hypertensive patients), and Group C (22 hypertensive patients on chronic effective treatment). The three groups were not significantly different in age, sex, education, social status, or working activity (table 1). During the tests, all the subjects were kept in the hospital. Group A and C subjects were in the hospital because of minor surgical or orthopedic disorders. Group B subjects came into the hospital to achieve a definite diagnosis for their persistently high levels of blood pressure. To avoid the influence of other conditions on neuropsychological performances, all the participants, randomly selected, had to present the following features: 1) be from 25 to 50 years of age; 2) have a negative history and examination for neurological disorders; 3) have a negative history, clinical examination, and laboratory data for diabetes mellitus, chronic alcoholism, dyslipidemias, and psychiatric troubles; 4) be on no psychopharmacological treatment; and 5) be right-handed.

All the subjects were informed of the aim of the study, and their consent was obtained. Blood pressure was measured according to standard parameters. Diastolic and systolic values of Group A subjects did not exceed 90 and 150 mm Hg, respectively, during morning measurement on three different days. Group B subjects had diastolic pressures that regularly exceeded 95 mm Hg. Group C patients had suffered for several years from hypertension and had been
TABLE 1. General Characteristics of Subjects Tested (Mean ± Standard Deviation)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group A n = 15 (7 M; 8 F)</th>
<th>Group B n = 17 (10 M; 7 F)</th>
<th>Group C n = 22 (13 M; 9 F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>39 ± 7</td>
<td>35 ± 9</td>
<td>43 ± 6</td>
</tr>
<tr>
<td>Education (yrs)</td>
<td>10 ± 4</td>
<td>9 ± 3</td>
<td>10 ± 3</td>
</tr>
<tr>
<td>Occupational code*</td>
<td>2.6 ± 0.6</td>
<td>2.5 ± 0.5</td>
<td>2.6 ± 0.4</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>77.3 ± 5</td>
<td>103.8 ± 7.6</td>
<td>92.2 ± 2.4</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>119.6 ± 7</td>
<td>160 ± 15.7</td>
<td>155.1 ± 15</td>
</tr>
<tr>
<td>Time elapsed since diagnosis</td>
<td>—</td>
<td>few weeks</td>
<td>8.3 ± 2 yrs</td>
</tr>
</tbody>
</table>

*Arbitrary occupational rating ranging from 1 (unemployed) to 4 (managerial position).

successfully treated, i.e., their diastolic pressures were below 95 mm Hg. All the Group C patients were given diuretics (chlorothalidone or chlorothiazide plus amiloride), while propranolol or reserpine was added in four and three patients, respectively, none took all three drugs. None of the treatments produced significant central nervous system (CNS) side effects that could affect cognitive performances.

Table 1 shows the mean blood pressure values of each group from measurements taken in three consecutive sessions at the same time of the morning. Diastolic and systolic pressures of Group A were significantly lower than those of Groups B and C. Group B differed from Group C only in the diastolic values, which were higher for Group B. All hypertensive patients suffered from essential hypertension.

Testing Protocol

We selected a battery of tests in common clinical use, which were administered in two sessions of 45 minutes each. The first session was used to evaluate general cognitive functions; the second was designed to assess some specific cognitive functions. The first session included the Card Sorting Test (CST), to evaluate attention and concentration;14 Raven's Progressive Matrices 1938 (PM '38), to estimate intelligence factor "g";18 and the Wechsler Memory Scale (WMS), to evaluate memory and learning.18 The second session included Benton's Visual Retention Test, form B, to test visual memory and visuospatial recognition;17 and the following subtests of the Wechsler-Bellevue Scale (WB): 1) "block design," to appraise eye-hand coordination and spatial analysis; 2) "similarities," to test abstractive reasoning; 3) "pictures arrangement," to test reasoning; and 4) "digit-symbol substitution," to test psychomotor ability.18

The tests were always administered by the same physician, trained in administering psychological tests, who was informed of the patient's group, while the psychologist who scored the tests was unaware of this condition. Standard scoring was used for the tests when provided (WMS and WB subtests). Learning was evaluated by considering the scores obtained on each subject from repetitive administration of the WMS subtest "word association." Subjects who learned all the items at the first administration had higher scores, while those obtaining the same result at the second or third administration scored proportionally lower.

In scoring the CST, decisional times were calculated. One point was awarded for each design correctly reproduced in the Benton test and the same scoring was used for PM '38. For statistical evaluation of the data, one-way analysis of variance was employed; when the outcome was significant, / tests were used to distinguish between group differences.

Results

Tables 2 and 3 give the mean scores obtained by the three groups in the battery test and statistical analysis; table 3 shows memory and learning performances of the three groups according to the WMS. It is impor-

<table>
<thead>
<tr>
<th>Test</th>
<th>Group A (x ± SD)</th>
<th>Group B (x ± SD)</th>
<th>Group C (x ± SD)</th>
<th>A vs B</th>
<th>A vs C</th>
<th>B vs C</th>
<th>A vs B + C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM '38</td>
<td>48.6 ± 9</td>
<td>34.1 ± 11.4</td>
<td>39.2 ± 9</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>CST</td>
<td>16.7 ± 6</td>
<td>20.4 ± 7</td>
<td>22 ± 8</td>
<td>NS</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Benton test</td>
<td>8.4 ± 1.3</td>
<td>8 ± 1.6</td>
<td>6.5 ± 2.3</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Similarities</td>
<td>12.2 ± 2.7</td>
<td>11.7 ± 2.6</td>
<td>12.1 ± 1.7</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Digit-symbol substitution</td>
<td>10.5 ± 3.5</td>
<td>9.3 ± 4.3</td>
<td>10 ± 2.8</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Pictures arrangement</td>
<td>10.6 ± 3.8</td>
<td>8.5 ± 2.8</td>
<td>8.4 ± 2.7</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Block design</td>
<td>14.8 ± 1.9</td>
<td>11.7 ± 3.4</td>
<td>12.4 ± 2.1</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
Table 3. Mean Scores (± standard deviation) and Statistical Analysis Obtained in WMS Subtests of Three Groups of Subjects

<table>
<thead>
<tr>
<th>Test</th>
<th>Group A (x ± SD)</th>
<th>Group B (x ± SD)</th>
<th>Group C (x ± SD)</th>
<th>A vs B</th>
<th>A vs C</th>
<th>B vs C</th>
<th>A vs B + C</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMS</td>
<td>118.8 ± 15</td>
<td>104 ± 17.4</td>
<td>105 ± 16.1</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Learning test</td>
<td>4.5 ± 1.7</td>
<td>3.8 ± 2.2</td>
<td>3.3 ± 1.7</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Short-term verbal memory</td>
<td>13.7 ± 1.3</td>
<td>12 ± 2.5</td>
<td>11.9 ± 1.9</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Long-term verbal memory</td>
<td>11.1 ± 2.8</td>
<td>10.4 ± 3.9</td>
<td>9.6 ± 1.9</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Short-term visual memory</td>
<td>8.2 ± 3.8</td>
<td>6.4 ± 4.7</td>
<td>7.4 ± 3.3</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

It is important to point out that in all tasks, the group of normotensive subjects (Group A) obtained better scores than did groups of hypertensive patients. Group A scores obtained in PM '38 were significantly higher than those of Group B, Group C, and Group B + C.

The mean decisional times on CST were significantly better in Group A than in Group C. In the Benton test, a significant difference was found in comparing Group A with C.

As for WB subtests, the scores obtained by the three groups in "similarities" and in "digit-symbol substitution" were not significantly different. Group A scored significantly better in the "pictures arrangement" as compared with Group C. The scores obtained by Group A in the "block design" test were significantly better than those obtained by Group B, Group C, and Group B + C.

The mean memory quotient obtained on WMS by Group A was significantly higher than that of Group B, Group C, and Group B + C. A detailed analysis of the WMS subtests showed that significant differences were found only in short-term verbal memory in comparing Group A with B, A with C, and A with B + C. The rate of learning was not significantly different in the three groups. No significant difference was observed in comparing the cognitive performances of males and females, either within or among the groups.

In spite of the relatively small size of our sample and the need for further studies, the results of the neuropsychological tests seem sufficiently clearcut to warrant the following conclusions:

**Group A vs B.** Recently recognized, untreated hypertensive patients show worse mnemonic performances, in addition to impairment of global intelligence and of visuospatial recognition, when compared with normotensive subjects.

**Group A vs C.** The same differences between Groups A and B are confirmed between Groups A and C. Moreover, hypertensive patients in chronic effective treatment show significant deficits of attention and abstract reasoning, as well as a further impairment of visuospatial recognition.

**Group B vs C.** No significant difference is observed in comparing the two groups of hypertensive patients.

**Group A vs B + C.** Hypertensive patients, when compared to normotensive subjects, show impairments of memory, intelligence factor "g," and visuospatial recognition. On the other hand, it must be stressed that hypertensive patients do not show significant impairment of attention and concentration; abstractive, psychomotor, and learning abilities, long-term verbal memory; and short-term visual memory.

Although quiet and homogeneous testing conditions were ensured for all the subjects, emotional reactions that may have impaired cognitive performances cannot be ruled out. However, we do not believe that this has significantly affected the validity of our results. The memory deficit observed in hypertensive patients is probably due mainly to impairment of short-term verbal memory, which, at least in Group C, may be related to attention deficit revealed by CST. Both PM '38 and the "pictures arrangement" test can be considered as logical reasoning tasks of decreasing abstraction: in Group B only the more abstract level (i.e., PM '38) was impaired, while in Group C a more concrete level was also compromised.

Failure in the Benton and "block design" tests (and partially also in PM'38 and "pictures arrangement" tests) can be considered a deficit of visuospatial recognition; this was mild for patients of Group B, and relatively severe for patients of Group C.

The experimental nature of our study does not allow any definite conclusions as to the influence of therapy and duration of illness on the cognitive processes of hypertensive patients. Our data seem to indicate the failure of therapy to reverse or arrest the progressive cognitive changes observed in hypertensive patients. In Group C, no significant difference in neuropsychological performance was observed in patients given diuretics alone and patients given diuretics and reserpine or propranolol, which are known to have possible effects on psychic functions. It seems possible that therapy in itself might influence attention as measured by CST. Investigations aimed at evaluating the possible effects of long-lasting treatments with each antihypertensive drug on cognitive processes are in progress.

The impaired performances of Group C on the visuospatial (Benton test) and logical reasoning tasks, even at the concrete level ("pictures arrangement"
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test), might be due to cerebrovascular changes produced by longer exposure to hypertension. In an earlier study of untreated newly recognized hypertensive patients, Boller et al. 19 found only mild memory disorders and longer reaction times compared with normotensive controls. We should point out, however, that a different methodology could account for the discrepancies observed. In our study, the test battery was designed not only to explore cognitive processes as completely as possible but also to reveal slight deficits such as those expected in asymptomatic hypertensive patients.

Our data agree with those of Wilkie and Eisdorfer 20 who, with a different experimental methodology, observed a negative correlation between the results of the Wechsler Adult Intelligence Scale Intelligence Quotient (WAIS IQ) and diastolic blood pressure tests in the elderly.

The first conclusion that can be drawn from our study is that the impaired cognitive efficiency often reported by hypertensive patients is reflected in the neuropsychological deficits disclosed by a battery of fairly sensitive tests. Unfortunately, the experimental design of our study does not allow any conclusion on the relative influence of possible cerebrovascular lesions, therapy, or emotional reactions on the cognitive deficits observed in hypertensive patients. Nevertheless, it seems worth stressing that the deficits we observed appear to pinpoint to cortical dysfunctions in the structures of the limbic system, a system essential for mnemonic processes, and to the right-hand temporoparietooccipital carrefour, which is known to be essential to visuospatial organization and recognition.

We attach great importance to studies that will shed light on how reliable neuropsychological deficits may be as indicators of heightened stroke incidence in hypertensive subjects.

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