ELECTROLYTES, ENVIRONMENT AND BLOOD PRESSURE

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SUMMARY

1. Studies to explain a significant socioeconomic and rural–urban blood pressure gradient found in central Mississippi are reported.
2. 24 h sodium excretion alone fails to explain the differences found, and fails to correlate with blood pressure.
3. A single 24 h determination of electrolyte excretion correlates modestly with the mean of 6 days' collection. Three days' collection and blood pressure determination is a reasonable compromise.
4. The urinary Na/Ca ratio is significantly higher in specimens from rural black girls compared with urban girls, and significantly higher in specimens from those with systolic pressure > 125 mmHg compared with those with < 105 mmHg pressure.
5. The urinary Na/K ratio of black girls was significantly higher than that of white girls of the same age, as was their blood pressure.
6. No correlation between blood pressure and urinary electrolytes could be found in black women aged between 35 and 45.

Our initial studies were carried out in the city and county schools of Hinds County, Miss., during the period 1965–67, among the four race–sex groups with observations on approximately 5000 black students and 5500 white students.

The following evidence was obtained that demonstrates an environmental influence on blood pressure in Jackson, Miss., U.S.A., and its surrounding county, Hinds.

1. Blood pressure was higher in rural students than city students.
2. In the city the pressure was inversely related to socioeconomic status.
3. The usual black–white blood pressure difference was abolished when black upper income girls were compared with rural whites, and significantly reversed in males when the same comparison was made (Langford, Watson & Douglas, 1968).

The correlation coefficient for diastolic blood pressure of black female sibling pairs aged
between 14 and 20 (0.379, 371 pairs) was higher than found in most studies and the correlation coefficient for half-siblings (0.354) was similar.

To search for electrolyte influences as possible causes of the environmental influences on blood pressure, the following studies have been done.

1. All negro female sibling pairs from the previous studies in which neither member had been pregnant or moved from the area were contacted. 24 h urine collections were obtained and the salt-taste threshold determined. The correlation of salt-taste threshold (0.445, 113 pairs) and sodium excretion (0.427, 81 pairs) was of the same order of magnitude as found for blood pressure. However, there was no correlation of sodium excretion or salt-taste threshold with blood pressure (Langford & Watson, 1972).

2. Failure to obtain significant correlation of blood pressure and sodium excretion could be due to variability of blood pressure and sodium excretion in individuals. To elucidate this the following study was done.

A proportionate random sample of black females previously identified in school were selected for study in their homes. Three blood pressure determinations were made daily for eight consecutive days. Each of these 100 girls also collected an overnight and rest of 24 h urine specimen for six consecutive days.

The following correlation coefficients were obtained for the urinary electrolytes:

<table>
<thead>
<tr>
<th>6-day mean excretion rate</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>First overnight sample</td>
<td>0.420</td>
<td>0.247</td>
<td>0.552</td>
</tr>
<tr>
<td>First 24 h sample</td>
<td>0.664</td>
<td>0.810</td>
<td>0.741</td>
</tr>
<tr>
<td>Mean (x) of first 3 days (24 h)</td>
<td>0.900</td>
<td>0.94</td>
<td>0.948</td>
</tr>
</tbody>
</table>

For blood pressure the following correlation coefficients were obtained with the mean pressure for 8 days' observation (twenty-four pressures).

<table>
<thead>
<tr>
<th>Systolic</th>
<th>Diastolic</th>
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<tr>
<td>First day (mean of three pressures)</td>
<td>0.787</td>
</tr>
<tr>
<td>First 3 days (mean of nine pressures)</td>
<td>0.921</td>
</tr>
</tbody>
</table>

The first day's pressures correlated less well with another single day (eighth day), 0.583 systolic and 0.613 diastolic.

3. The failure to find correlation of sodium excretion and blood pressure could be due to the participation of other electrolytes in induction of hypertension. The analysis of the dietary histories obtained from the siblings at the time of their urine collection revealed that those with lower pressures (<105 mmHg systolic) consumed more calcium than those with higher pressures (>125 mmHg systolic). The Na/Ca ratio in the 24 h urines of the two groups also differed being mean = 20.4, n = 28 and mean = 34.4, n = 27 respectively (P < 0.05). The Na/Ca ratio was higher (less Ca) among the rural females than among the urban females (mean = 33.6 vs 24.7, P < 0.05). An inverse gradient was also demonstrated between socioeconomic level and Na/Ca excretion.

24 h urines were collected on ninety-seven white girls, with average age of 20 years, and on 101 black girls of the same age. The blood pressure of the black girls was significantly higher.
Electrolytes, environment and blood pressure

than that of the white girls, the sodium excretion was non-significantly higher in the black girls, but the urinary Na/K ratio was significantly higher (4.26 ± 2 vs 2.98 ± 1, P < 0.05.)

We have obtained single-day blood pressure measurements and urine collections on 198 older negro females (ages 34–44). No correlation between blood pressure, either systolic or diastolic, and Na, K, Ca or the Na/K, and Na/Ca ratios was demonstrated. When this group was partitioned into high (25%), middle (50%) and low (25%) blood pressure groups, no differences in electrolyte excretions were observed between the groups. A linear trend was noted for sodium excretion with more excreted by the high group but the differences did not approach significance (P > 0.25).

We have listed above evidence to suggest that an environmental force is affecting the blood pressure of our study population. As measured by a single 24 h urine, sodium seems inadequate to explain the difference found, or to differentiate those with higher pressures from the girls with lower pressures.

Alternative explanations may be entertained.

1. Sodium intake has nothing to do with the genesis of blood pressure differences.
2. Sodium intake is a significant factor in such a small subset that the correlation cannot be identified in a population study.
3. Sodium intake acts at an earlier age than any that we have studied.
4. Variability of blood pressure and sodium excretion masks any real effect. This possibility is a very real one. We suggest that three blood pressure determinations daily, and three 24 h urine collections should be used in future studies.
5. The blood pressure-raising effect of sodium is substantially modified by other electrolytes.

The two ions which we nominate at the present are as follows.

(a) Calcium. The correspondence of the Na/Ca ratio with the socioeconomic blood pressure gradient, and the higher Na/Ca ratio found at the upper end of the blood pressure distribution curve compared with the lower suggests that this factor is operative.

(b) Potassium. The Na/K ratio in the urine of black girls was significantly higher than that found in the white girls of the same age. Rat studies support the protective influence of K (Dahl, Leite & Heine, 1972). We think potassium may be an important determinant of the blood pressure-raising effect of sodium.

We propose the following hypothesis: that in the salt-sensitive portion of the population, the development of hypertension will be a direct function of net sodium intake, and an inverse function of potassium and calcium intake.

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REFERENCES