EFFECT OF HIGH-SALT, HIGH-CARBOHYDRATE, LOW-PROTEIN DIET ON HYPERTENSION IN THE RAT

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SUMMARY

1. High-salt, high-carbohydrate and low-protein diet induces remarkable elevation of blood pressure in spontaneous hypertensive rats (SHR).
2. These animals have low serum potassium, low blood urea nitrogen and high blood sugar.
3. Heart weight is increased in proportion to the elevation of blood pressure.
4. Kidney weight of rats receiving the high-salt, high-carbohydrate and low-protein diet was, by contrast, smaller than SHR receiving a normal diet.
5. The kidneys of SHR receiving a high-salt, high-protein diet were twice as heavy as the kidneys of normal rats.
6. Similar dietary modifications in Goldblatt hypertensive rats to those in SHR produced similar changes in blood pressure and heart weight.

Key words: spontaneous hypertension, diet, optic fundus, heart weight.

It has been reported that the incidence of hypertension is high in Northern Japan where the customary diet is predominantly of rice with a high content of added salt. In addition to being high in carbohydrate and salt, this diet has a low protein content. Whereas it is generally accepted that experimental hypertension can be induced in animals by the continuous administration of salt, the role of protein, fat and carbohydrate in the aetiology of hypertension is less clear. This paper is concerned with the effects of a high-salt, high-carbohydrate and low-protein diet on the blood pressure, eyeground appearances, biochemistry and autopsy findings of spontaneously hypertensive rats (SHR) and Goldblatt rats.

METHODS AND MATERIALS

Diets

A 1% salt solution was given to groups of rats receiving a high salt intake. The normal diet

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contained 21% protein, 6% fat, 56% carbohydrate. High-salt, high-fat diet (S₁) contained 12% protein, 58% fat, 16% carbohydrate. High-salt, high-protein diet (S₂) contained 64% protein, 4% fat, 14% carbohydrate. High-salt, high-carbohydrate, low-protein diet (S₃) contained 5% protein, 5% fat, 82% carbohydrate.

Rats

Forty-eight female SHR of generation F₂₄ were used, twelve Wistar rats serving as controls in this part of the study. Systolic blood pressure was measured by the tail water-plethysmographic method from the fifth week after birth. The forty-eight SHR were divided into four groups, each of which received a different experimental diet: the control Wistar (C₁) and one group of twelve SHR rats (C₂) received the common diet; the other three SHR groups received diets S₁, S₂ and S₃. The experimental diets were introduced at the age of 6 weeks, the blood pressure being measured weekly. Ten weeks after the introduction of the special diets, half of each group of rats was killed and blood was sampled for biochemical analysis. The main organs were removed, weighed and then examined histologically. At 14 weeks from the start of the special diets, three further rats of each group were killed for similar studies.

Goldblatt hypertension was induced in female rats of the Dawley strain (weight 90-100 g). Blood pressure was measured by the microphonic cuff method every 2 weeks. Goldblatt hypertension was induced by constricting the left renal artery with a silver clip, a right nephrectomy being performed 1 week later. Five weeks after operation the animals were divided into four groups which respectively received the control (C) diet, and the various high salt diets S₁, S₂, S₃.

RESULTS

Spontaneous hypertension

The SHR fed with diet S₁ showed the highest blood pressure, whereas those receiving the standard diet showed the lowest mean blood pressure amongst the SHR groups (Fig. 1). The body weights of control SHR and S₂ groups were higher than those of normal Wistar rats and those (S₁) receiving the high-salt, high-fat diet. The low-protein group (S₃) showed lower body weights in the earlier stages of experiments, but at the end of 14 weeks body weights in this group had reached the level of those in the high-fat (S₁) group.

The optic fundus of SHR of 17 weeks of age shows narrowing, tortuosity and irregularity of calibre of the retinal arterioles. The SHR given the high-salt and high-fat diet for 12 weeks (S₁), showed markedly narrow arterioles and greater irregularity of calibre. The high-salt, high-protein SHR group (S₂) showed broader arterioles than the S₁ and S₃ groups. The fundus of animals in group S₃ showed extensive narrow and tortuous retinal arterioles together with capillary dilatation and haemorrhages.

Urinary volume was increased in all groups receiving the high-salt diet; slight albuminuria was also noted in the high-protein group, S₂.

Biochemical analysis of serum showed the following features: the S₃ group had low potassium, low total protein, low blood urea nitrogen (BUN) and high blood sugar. The S₁ group had high cholesterol and high alkaline phosphatase. The S₂ group had low cholesterol and high BUN.

The heart weights and blood pressure increased in the order: control Wistar rats→control SHR→S₂→S₁→S₃.
Diet and hypertension

The values of (kidney weight/body weight) × 1000 were as follows: normal Wistar 1.41; normal SHR 1.69; S1 1.71; S2 2.59; S3 1.55. Thus the high-salt, high-protein diet in SHR induced marked enlargement of the kidney, whereas the kidneys of SHR on high-salt, high-carbohydrate and low-protein diet were relatively small.

Goldblatt rats

The changes of blood pressure in Goldblatt rats after 9 weeks of experimental diets were as given in Table 1.

Heart weights correlated well with hypertension in each dietary group. The heart weight index was calculated as (heart weight/body weight) × 1000, the values in the various groups being as follows: C (Goldblatt rats taking control diet) 3.2; S1 5.1; S2 4.9; S3 5.6.

More detailed information concerning the studies reported here are given in the following

Table 1. Changes in blood pressure in Goldblatt rats after 9 weeks of experimental diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>Change in mean BP (mmHg)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>144 to 152</td>
<td>6</td>
</tr>
<tr>
<td>S1 (high-salt, high-fat)</td>
<td>158 to 187</td>
<td>18</td>
</tr>
<tr>
<td>S2 (high-salt, high-protein)</td>
<td>147 to 170</td>
<td>16</td>
</tr>
<tr>
<td>S3 (high-salt, high-carbohydrate, low-protein)</td>
<td>147 to 194</td>
<td>32</td>
</tr>
</tbody>
</table>
papers: Ueda, Iwai & Yasuda (1969); Ueda, Nishimura & Yasuda (1967); Ueda, Matsuo & Yasuda (1968); Okamoto et al. (1972); Umehara, Sasaki, Kudo & Mori (1972); Hazama et al. (1972); Irinoda, Matsuyama & Takahashi (1972).

REFERENCES


