Effects of High Carbohydrate or Protein Diets on Blood Pressure of Normotensive and Hypertensive Dogs

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The effects of diets high in carbohydrate or protein were studied on four dogs when normotensive and later when hypertensive. The results suggest that under certain conditions a cardiovascular homeostatic relationship may exist between diet, VEM-VDM, and the sympatho-adrenal system.

Previous studies\(^1\) showed that when normal dogs were subjected to a prolonged fast and realimented with diets high in carbohydrate fed at the luxury consumption level of 120 cal./M.\(^2/\)hour they developed a high systolic pressure and a rapid pulse with a low diastolic pressure. This systolic hypertension would usually persist as long as the diet was eaten. When normal fasted dogs were realimented with luxury consumption diets high in protein, the blood pressure and pulse rate rose moderately above the low fasting level but finally stabilized below the control values. Isocaloric luxury consumption diets high in carbohydrate or protein appeared to have antagonistic actions on the blood pressure of normal dogs.

We have been able to produce a prolonged diastolic hypertension in 4 dogs by the use of diets containing from 50 to 70 per cent of the calories from animal fat and concomitant dietary stresses. Previous publications have dealt with: the experimental design and the first circulatory abnormality to appear\(^2\) a nosographical study of the genesis and development of the hypertension;\(^3\) and a statistical study of the fully developed condition;\(^4\) and this material will not be repeated here. The purpose of the present paper is to show the effects of luxury consumption diets high in carbohydrate on the blood pressure and heart rate of these dogs when normotensive and later when hypertensive and to show the effect of substituting an isocaloric high protein diet for the high carbohydrate diet during the hypertensive state.

**MATERIALS AND METHODS**

The 4 dogs (2 males and 2 females) used in the present studies had been used in blood pressure studies for over 5 years and during this period blood pressure and heart rate had been determined 5 to 6 days each week with almost no interruptions; consequently the animals were well trained and the control values were well established. The diastolic hypertension of dietary origin had been present for approximately 3 years and was highly significant both statistically and physiologically\(^5\).

In the present studies, blood pressure was determined 5 to 6 days each week by the auscultatory method of Allen\(^6\) with certain modifications and improvements.\(^7\) The daily values were the mean of from 10 to 15 consecutive determinations.

**Diets**: Boiled white rice or cracker meal moistened and flavored with Difco beef extract and fed at the luxury consumption level of 120 cal./M.\(^2/\)hour were used as the high carbohydrate diets. A tablespoon of brewers yeast was added to the diet and one multivitamin\(^8\) tablet was given daily. Ground raw horse meat fed at the level of 120 cal./M.\(^2/\)hour was used as the high protein diet. No brewers yeast or vitamin pills were given when on the meat diet.

In the present studies, the hypertensive animals were subjected to a preliminary fast of 23 days during which there was no decline in blood pressure.\(^7\) They were then realimented with the high

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*Multicebrin (Lilly) contains the daily human requirement of the most important vitamins.*

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carbohydrate diets. Previous studies showed that there were no hemodynamic differences between rice and cracker meal, hence, dogs 1 and 4 were fed rice and dogs 2 and 3 were fed cracker meal. These diets were continued for a period of 35 days and were eaten avidly. At the end of this period and with no preliminary fast, the diet was suddenly changed to an isocaloric diet of horse meat which was continued for 70 days.

The animals were fed at 3:00 p.m. daily and blood pressure and pulse rate were determined between 6 and 10 a.m. with a specific time for each dog.

During the normal and control hypertensive periods (periods 1 and 3, fig. 1) each dog was fed the same weighed amount of Nutrena dog food which had been found to keep the particular animal at an optimal weight.

RESULTS

The data on the 4 dogs are shown in figure 1. For each dog, period 1 shows the control blood pressure and heart rate on the standard kennel diet of Nutrena. The controls were done at frequent intervals over a period of several years and the total number of days on which control blood pressure and pulse rate were determined were 124, 113, 89, and 168 for dogs 1-4 respectively. The individual daily values were combined statistically to give a single mean for each dog. The pressures during the various control periods were all similar and there was no evidence that a spontaneous elevation was occurring.

Period 2 shows the hemodynamic effects of a luxus consumption diet of rice or cracker meal fed for 90 days after a prolonged fast, before the production of the diastolic hypertension. Each dog shows the typical elevation of the systolic pressure and pulse rate with either no change or a minimal elevation of diastolic pressure.

Period 3 shows the diastolic hypertension produced by dietary stresses and diets high in animal fats. In each dog the systolic and diastolic pressures were elevated above the control levels and the probability of the elevations were <0.01 when calculated from t. In dogs 1, 2 and 4 the heart rate during the period of hypertension was significantly lower (p <0.01) but it was significantly higher (p <0.01) in dog 3.

Period 4 shows the effect of the luxus consumption diets of cracker meal or rice during the entire period of 35 days after the production of the diastolic hypertension. In each dog these diets caused a decrease of both the systolic and diastolic pressures, the decrease of the diastolic always being greater than that of the systolic. As shown in the table, the probabilities of the decreases in pressure ranged from <0.05 to <0.01. In each dog the heart rate was higher than during the hypertensive period (p <0.01).

In dogs 1, 3, and 4 the pressures were lower during the last 5 days than during the entire 35 day period on the carbohydrate diet. This is illustrated in period 5. In dog 1 the systolic and diastolic pressures reached the original control values during these last 5 days.

Period 6 shows the effect of the luxus consumption diet of protein for the entire period of 70 days, while period 7 shows the last 28 days of the 70 day period. In each dog the high protein diets antagonized the effect of the high carbohydrate diets and the systolic and diastolic pressures rose to or above the
**EFFECTS OF DIET ON BLOOD PRESSURE**

**Table 1.—Effect of High Carbohydrate Diet after Preliminary Fast during Hypertension**

<table>
<thead>
<tr>
<th>Dog</th>
<th>Hypertensive period</th>
<th>Entire period on high carbohydrate</th>
<th>Difference</th>
<th>Probability of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>D</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td>1</td>
<td>133</td>
<td>79</td>
<td>56</td>
<td>124</td>
</tr>
<tr>
<td>2</td>
<td>166</td>
<td>102</td>
<td>53</td>
<td>145</td>
</tr>
<tr>
<td>3</td>
<td>133</td>
<td>100</td>
<td>82</td>
<td>126</td>
</tr>
<tr>
<td>4</td>
<td>153</td>
<td>105</td>
<td>71</td>
<td>145</td>
</tr>
</tbody>
</table>

S, systolic; D, diastolic; P, pulse pressure.

original hypertensive level while the pulse rates decreased.

The effect of the high protein diet in annuling the hypotensive effect of the high carbohydrate diet occurred very promptly as shown in figure 2 (dog 1).

**DISCUSSION**

The etiology of the diastolic hypertension produced by high fat diets and dietary stresses (fasting, marked obesity, and drastic reduction diets) is unknown but one important negative finding has been established, namely that the plasma level of 17 hydroxycorticisone is well within the normal level for dogs (1-4 μg./100 ml.).

Assays kindly made by the late Professor Ephraim Shorr showed that samples of blood from dogs 2 and 3, when on the high carbohydrate diet during the normotensive period, had high VEM activity in the unfractionated specimens. On fractionation, VDM activity was also demonstrated and shown to be due to the presence of ferritin. Blood from control dogs or the same dogs on the standard kennel diet were negative for VEM and VDM.

The important aspect of the present investigations is that when the effect of the high carbohydrate diet was annulled by the high protein diet, the systolic and diastolic pressures of dogs 1, 3 and 4 rose above the original hypertensive levels. This suggests that when hypertensive levels of blood pressure are lowered without removing the cause, there is a stimulation of the blood pressure elevating mechanisms with a resulting rebound of the pressure when the hypotensive agent is removed. This hypothesis possibly explains the following observations: (1) During the development of the diastolic hypertension of dietary origin it was noted that when the pressure fell spontaneously to low or normal levels, or when it was artificially lowered by an intravenous injection of histamine, the period of low pressure was nearly always followed by a sharp rise to levels higher than those before the fall; (2) during drug therapy of human hypertension, discontinuance of therapy after a low or normotensive level has been attained is often followed by a marked rebound of pressure with disastrous results.

As previously reported, the systolic hypertension with rapid pulse and a low or normal diastolic pressure will be maintained for prolonged periods of time only when the luxus consumption high carbohydrate diet is given after a prolonged preliminary fast. Recently we have shown that the specific hemodynamic effects of fasting and of the high carbohy-
drate diets are dependent on the sympathetic-adrenal medullary system since neither occur in dogs after a bilateral paravertebral ganglionectomy with denervation of the adrenal glands.9

These facts plus the results reported in the present paper suggest that under certain conditions, diet, the sympathicoadrenal medullary system and VEM-VDM may constitute an integrated cardiovascular homeostatic system.

**SUMMARY**

Four dogs were studied when normotensive and later when hypertensive. During the normotensive period they were subjected to a preliminary fast and realimented with high carbohydrate diets fed at the level of 120 cal. M./hour. As a result they developed a high systolic pressure and a rapid pulse with a low diastolic pressure. VEM and VDM were demonstrated in the blood plasma. It was previously shown that substitution of an isocaloric high protein diet antagonizes the effect of the high carbohydrate diet.

During the hypertensive period they were fasted and realimented with the high carbohydrate diet. This caused a lowering of both the systolic and diastolic pressure. An isocaloric high protein diet antagonized the carbohydrate effect and caused the pressure to rise above the original hypertensive levels. These studies plus other recent findings suggest an integrated hemodynamic homeostatic relationship between diet, the sympathico-adrenal system and VEM-VDM.

**SUMMARIO in Interlingua**

Quatro canes esseva studiate in stato de normotensivitate e plus tarde quando illos esseva hypertensive. Durante le periodo normotensive le canes esseva subijeite a un jeuno preliminari sequite per realimentation con dietas ric in hydratos de carbon que esseva administrate al mesura de 120 cal. per m² per hora. Le resultato esseva que le canes disveloppava un alte pression systolic e un pulso rapide con base pression diastolic. Materiales vaso-excitatori e vaso-depressori esseva demonstrate in le plasma del sanguine. Il esseva mostrate previemente que le substitution de un isocaloric dieta ric in proteina antagonisa le effecto del dieta ric in hydratos de carbon.

Durante le periodo de hypertension, le canes esseva de novo subijeite a un jeuno preliminari e realimentate con le dietas ric in hydratos de carbon. Isto resultava in un reduction del pression systolic e etiam del presision diastolic. Un dieta isocaloric ric in proteina antagonisava le effecto del hydratos de carbon e faceva le pressiones montar a supra le nivellos hypertensive original. Iste studios, insimul con altere constatationes recente, suggere le existentia de un integrate relation homeostatic hemodynamic inter le dieta, le systema sympathico-adrenal, e le materiales vaso-excitatori e vaso-depressori.

**REFERENCES**


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