

# DEPRESSOR EFFECTS OF POTASSIUM-DEFICIENT DIETS IN HYPERTENSIVE MAN<sup>1</sup>

By GEORGE A. PERERA

(From the Department of Medicine, Columbia University College of Physicians and Surgeons, and the Presbyterian Hospital, New York, New York)

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The relationship of the sodium ion to blood pressure levels in certain hypertensive states is now established beyond cavil. But whether alterations are mediated through the adrenal cortex, through renal or other pressor mechanisms, or through modification of neuromuscular responses at an arteriolar plane, cannot be stated at the present time.

In recent years the potassium ion has been considered in other ways than its known effects on cardiac muscle contraction or on synaptic transmission. Potassium chloride-flooding in rats has been reported to induce an increased renal and a decreased cardiac weight as well as hypertrophy of the adrenal glomerulosa zone (1). Furthermore, Freed, Friedman and Rosenman have demonstrated that dietary potassium restriction will lower the blood pressure in normal and hypertensive rats, block the pressor effects of desoxycorticosterone, and reduce peripheral vascular reactivity (2-5).

The present study was undertaken to investigate the effects of potassium-deficient diets in hypertensive man, with the hope that further light might be thrown on the mechanisms involved in sodium restriction.

## METHODS

Five observations were made on four patients with hypertensive vascular disease, uncomplicated save that two had sustained relatively minor cerebral vascular accidents at least a year before. The conditions, diagnostic procedures and methods<sup>2</sup> were similar to those reported previously (6), including the utilization of "resting" blood pressure measurements, constant dietary and fluid intakes,

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and preliminary periods of hospital supervision of about three weeks. Desoxycorticosterone acetate was administered subcutaneously in 5 mg. doses once daily.

Identical salt-poor daily menus were prepared as before (6), with sodium chloride administered by mouth from weighed salt shakers to yield a total daily intake of about 4 grams. Potassium restriction was achieved (without change in total fluids, calories, sodium or the addition of special ingredients) by almost complete elimination of fruit juices, potato, milk and eggs, reduction of meat and coffee, selection of certain fruits, cereals and vegetables, and the addition of fats, sugar and ginger ale. This resulted in a decreased protein intake (ranging in different patients from 69 to 84 grams per day in the control period, to 31 to 48 grams while on the curtailed regimen) and an increase in the consumption of fat. Repeated direct analyses of aliquots taken from an entire day's cooked diet confirmed the constancy of the regimen.

## RESULTS

Tabular representation of the results is summarized in Table I and an illustrative case record is shown in Figure 1. The restriction of potassium, to approximately a third or a quarter of normal intake, was associated with a small but consistent and statistically significant decrease in

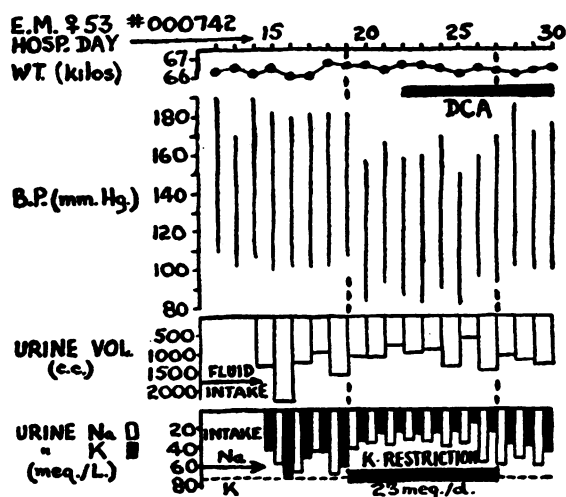


FIG. 1. CLINICAL AND LABORATORY DATA OF HYPERTENSIVE PATIENT GIVEN POTASSIUM-DEFICIENT DIET

TABLE I  
Effects of potassium-deficient diets in hypertensive subjects

	Diet; duration days	K intake mEq./d.	"Resting" B.P.			Urine (av./day)			Serum				H'crit % cells	Weight Start-End kilos
			Max.	Min.	Mean	Vol. cc.	Na	K	Na	K	Cl	CO <sub>2</sub>		
P. I.	control (10)	94	176 112	166 106	170 108	2215	67	75	138	4.4	102	30.1	47	
	low K (9)	23	172 102	154 92	164 100	1998	41	52	141	4.1	102	31.5	46	74.4-74.0
E. M.	control (8)	72	190 110	170 100	182 105	1472	60	58	137	4.1	102	27.1	36	66.4-66.6
	low K (3)	23	166 92	158 84	161 87	1277	34	26	137	4.3	104	28.1	34	66.6-66.6
	low K + DCA (5)	23	170 96	150 82	162 89	1060	39	21	137	3.6	105	27.6	36	66.6-66.5
	control + DCA (3)	72	186 102	172 100	178 101	1147	57	39						66.5-66.5
L. P. (1)	control (5)	67	180 100	170 96	174 99	1810	66	56	142	4.6	102	30.6		67.4-67.0
	low K (3)	21	166 88	164 86	165 87	1743	27	31	142	4.4				67.0-66.9
	low K + DCA (4)	21	174 94	154 86	162 88	1825	32	30	143	4.0	100	30.6		66.9-67.9
	control + DCA (4)	67	178 100	164 90	170 96	1770	51	42						67.9-68
L. P. (2)	control (5)	67	158 90	150 86	153 88	1973	65	57	143	4.4	102	30.0		67.1-66.9
	low K (4)	21	146 86	142 80	143 82	1900	31	32	142	4.2	100	28.0		66.9-66.9
	low K + 57 mEq. KCl (3)	78	164 96	160 90	162 93	2113	91	43						66.9-66.2
	low K (3)	21	158 86	154 82	156 84	2166	69	30						66.2-65.9
M. L.	control (10)	80	196 120	182 114	189 118	1570	71	63					45	
	low K (8)	20	176 112	156 96	164 103	1500	36	38					44	
	control (10)	80	192 116	180 110	185 114	1510	68	58					44	

"resting" blood pressure in every instance. This response appeared not later than 48 hours after diet modification and often within 24 hours, and the "resting" blood pressure rose promptly in those cases in which potassium chloride was added to the diet or when control diets were restored.

Curtailment of dietary potassium was followed

by a decrease in the amount excreted in the urine, but in general these values remained larger than the intake with a resultant negative balance, perhaps reflected in the serum potassium concentrations which fell slightly in three of four studies. Urinary nitrogen determinations were made in one patient and showed a decrease in proportion to the

reduced protein intake, thereby indicating that protein breakdown was contributing a negligible amount to the urinary potassium excreted during the limited period of these observations. In association with the restriction of potassium, urinary sodium excretion decreased sharply with an average positive balance, assuming other excretory routes were not invoked, of approximately 30 mEq. per day. Serum sodium concentrations, however, were not affected.

Except for a slight increase in constipation in two subjects, the restriction of potassium gave rise to no subjective distress. The shifts in electrolytes were unassociated with any major fluid alterations, at least as reflected in weight, hematocrit and urinary volume measurements, and in one subject the serum volume (calculated by means of the blue dye T. 1824) remained unaffected. Serum chloride and carbon dioxide content were not modified consistently. No patient was observed to develop urinary ketone bodies, and serum urea nitrogen values did not increase. Serial electrocardiograms and ballistocardiograms were obtained at frequent intervals in the course of two studies; the results were superimposable, nothing being found to suggest changes in cardiac function, intracardiac electrolyte alterations, or difference in the impact of the cardiac contraction.

In two instances, desoxycorticosterone acetate was administered while the patients were on the restricted diet. The "resting" blood pressure remained reduced until the control diet was resumed.

#### DISCUSSION

The decrease in "resting" blood pressure in response to short-term restriction of dietary potassium, observed six times in five studies on four patients with hypertensive vascular disease, confirms the reports of Freed, Friedman and Rosenman employing even greater restriction in hypertensive rats. It is noteworthy, with respect to the known therapeutic effects of salt restriction, that this phenomenon takes place despite rather marked sodium retention and, presumably, a rise in intracellular sodium (7-10).

The mechanism of the fall in blood pressure remains obscure. It appeared unrelated to serum volume changes in the one individual in whom measurements were made. It could not be ac-

counted for by the decrease in protein intake, necessary to achieve the potassium restriction, for the initial degree of hypertension could be restored in one instance merely by the addition of potassium chloride; nor, incidentally, will protein supplementation alter the arterial tension when reduced by the "rice diet" (11). It is doubtful that the depressor effects can be related to loss of potassium from heart muscle and a resultant fall in cardiac output, although this possibility cannot be excluded completely; against such a mechanism are the rapidity of the blood pressure decrease, the absence of abnormally low serum potassium values, and the lack of alterations in the electro- and ballistocardiograms. With reference to the role of the adrenal cortex, one might presume that a high rather than a low potassium intake should be analogous to a low sodium regimen; nevertheless, the fact that a low potassium diet blocks the customary pressor response of hypertensives to desoxycorticosterone (12), also noted previously in the rat studies (4), makes it possible that the adrenal cortex is one of the areas requiring further consideration. Finally, it is possible that electrolyte imbalance exerts a direct effect on neuromuscular transmission and hence a direct effect on the physiological site of hypertension, the arterioles; marked sodium deficiency has been reported to give rise to a neuromuscular block and a reduced output of acetylcholine (13).

From these preliminary studies it cannot be concluded that potassium restriction is of therapeutic benefit. The diets employed were unpalatable and unbalanced, particularly with respect to protein. Had they been made more restrictive or continued for longer periods, signs and symptoms and dangerous cardiac complications might have been produced. These observations do serve, however, to point again to the relationship of certain cations to the hypertensive state—perhaps through the intervention of the adrenal cortex, but perhaps through some direct action on blood vessel walls.

#### SUMMARY

1. The restriction of dietary potassium, undertaken six times in four patients with hypertensive vascular disease, was followed rapidly by small but statistically significant decreases in "resting" blood pressure.

2. Sodium retention accompanied the restriction of potassium.

3. The low potassium diet blocked the pressor response to desoxycorticosterone.

4. This study, confirming previous reports of hypotension observed in potassium-deficient rats, fails to exclude the possible participation of the adrenal cortex but is compatible also with the possibility of a direct role of cations upon neuromuscular transmission or upon blood vessel walls during the hypertensive state.

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