SOME MECHANISMS OF THE CHANGES IN KIDNEY FUNCTION DURING CONVULSIONS

A. A. Lebedev

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There are few references in the literature to changes in kidney function and, in particular, to the mechanisms of these changes, during convulsions. All that can be found are statements indicating the role of the efferent nerves, adrenalin, and serotonin in the mechanisms by which the convulsion influences kidney function [3-6].

The author [1, 2] has shown that an experimental convulsion causes considerable and prolonged changes in the basic renal processes: filtration, reabsorption of water, electrolytes, and nonelectrolytes, and also the excretion of foreign substances. Experiments in which osmotically active substances were administered to animals showed that the antidiuretic hormone of the pituitary is the leading factor in the mechanisms of the increase in the reabsorption of water by the tubular epithelium. However, the role of direct reflex influences of the adrenal medulla – the principal depot of adrenalin – in the changes in filtration, reabsorption, and secretion in the kidneys during convulsions remains incompletely understood.

It was therefore decided to study the above-mentioned factors and to demonstrate their role in the combination of mechanisms regulating the activity of the kidneys.

EXPERIMENTAL METHOD

To determine the role of direct reflex influences on the function of the vascular and tubular apparatuses of the kidneys the method of denervation of the kidneys in situ and of denervation of autotransplantation of the kidney into the neck in dogs were used. Experiments were carried out on five dogs: 3 with a transplanted right kidney and 2 with a right kidney denervated in situ.

To prevent the entry of adrenalin from the adrenals into the blood stream during the convulsion, in two dogs with an autotransplanted kidney the right adrenal was removed and the medulla of the left adrenal was treated by the thermocoagulation in two separate stages.

As a substance producing a convulsion, a mixture of ether and camphor was used, 1.5–2 ml being injected intravenously.

Experiments were carried out against the background of water diuresis produced by introduction of water (50 ml/kg) into the stomach. The glomerular filtration was studied by relation to inulin, and the renal plasma flow and tubular secretion in relation to phenol red. Between 20 and 30 min after the beginning of injection of the solutions of inulin and phenol red, when the concentration of these substances in the blood became optimal, two 15-min samples of urine were collected, and in the middle of each 15-min period blood was taken from a vein for analysis. Next the ether–camphor mixture was injected intravenously. After the end of the convulsion, the injection of the solution was resumed, a further 3 samples of urine were collected, and blood was taken from the vein. The concentrations of inulin and phenol red in the blood plasma and the urine was determined colorimetrically.

EXPERIMENTAL RESULTS AND DISCUSSION

In all the experimental dogs the convulsion led to marked inhibition of water diuresis for 45-60 min in both the intact and the denervated kidney. In a series of experiments, a less marked decrease in diuresis could be seen from the denervated or transplanted kidney than from the intact, although this difference could not be detected constantly.

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TABLE 1. Changes in Diuresis, Coefficient of Inulin Clearance, Inulin Concentration Index, and Excretion of Phenol Red in the Transplanted and Intact Kidneys after a Convulsion in the Dogs Ugryum, Bobik, and Deza

Index of kidney function	Statistical index	Before convulsion		After convulsion					
				15 min		30 min		45 min	
		Transplanted	Intact	Transplanted	Intact	Transplanted	Intact	Transplanted	Intact
Diuresis (in ml/min/m²)	$M \pm m$	3,27±0,34	3,25±0,39	0,22±0,05	0,13±0,04	0,32±0,06	0,43±0,06	1,16±0,13	1,00±0,06
Coefficient of inulin clearance (in ml/min/m²)	$M \pm m$	52,52±3,16	53,04±3,43	16,32±3,21	11,13±4,26	28,75±3,82	31,23±4,82	54,32±5,65	61,03±8,51
Inulin concentration index	$M \pm m$	19,34±3,88	21,49±5,68	85,27±8,63	86,00±12,15	102,18±11,96	108,27±12,70	74,27±9,34	89,12±10,64
Excretion of phenol red (in mg/min/m²)	$M \pm m$	2,09±0,19	2,15±0,21	0,64±0,13	0,38±0,14	1,46±0,14	1,45±0,28	2,16±0,24	2,05±0,17

The changes in the coefficient of clearance of inulin (glomerular filtration) and phenol red (renal plasma flow) were identical in the transplanted (denervated) and intact kidneys. The decrease in these indices was greater in the kidneys with intact innervation, although in relation to diuresis, the differences observed were not constant.

The mean values of the diuresis in the control period, before the convulsion, from the kidney denervated in situ and the intact kidney were different: the diuresis from the denervated kidney was slightly less than from the intact, although this difference was not statistically significant ($P > 0.1$). In the first 15 min after the convulsion, the decrease in diuresis from the denervated kidney was less marked than from the intact (0.48 ± 0.29 and 0.23 ± 0.14 respectively), this difference being statistically significant ($P < 0.05$). In the subsequent periods of observation the diuresis from both kidneys was practically identical, and the slight differences observed were not statistically significant.

The coefficient of clearance of inulin in this group of experiments in the preconvulsion period was the same for both kidneys (57.04 ± 19.22 for the denervated and 55.25 ± 22.93 for the intact kidney). The convulsion produced an equal decrease in the coefficient of inulin clearance in both kidneys, and no difference could be found even in the first 15 min ($P > 0.5$).

The changes in the coefficient of clearance of phenol red agreed fully with the changes in the coefficient of inulin clearance.

Since the changes in glomerular filtration after the convulsion were the same in both kidneys, it may be assumed that the reason for the differences in the decrease in diuresis from the intact and denervated kidneys was the less marked increase in the reabsorption of water in the latter. Analysis of the inulin concentration index (the index of the degree of concentration of the urine) suggested that the tubular reabsorption of water in the denervated kidney increased to a lesser degree after the convulsion (to 45.0 ± 19.85 in the first 15 min) than in the intact kidney (73.12 ± 29.66; $P < 0.05$).

Some progress toward discovery of the role of the efferent nerves in the mechanism of the effect of convulsions on kidney function may be made as a result of experiments on dogs with an autotransplanted kidney. Such a kidney can be regarded as an organ with all its connections with the external nervous system completely interrupted.

The results of experiments conducted on the dogs Ugryum, Bobik, and Deza, with a transplanted right kidney, differed significantly from the results of the experiments on the dogs with a denervated kidney. The decrease in diuresis and in the coefficient of inulin clearance after the convulsion were greater in the intact kidney than in the transplanted kidney, but the differences were not significant even during the first 15-min interval (Table 1). No differences likewise could be found in the changes in the inulin concentration index.

The changes in the excretion of phenol red after the convulsion were similar in both groups of experiments and took the form of a decrease in both the intact and the transplanted kidney.

Exclusion of the reflex secretion of adrenalin from the adrenals into the blood stream as a result of cauterization and necrosis of the medulla of the left adrenal and removal of the right adrenal from the dogs Bobik and Ugryum led to a change in the ratios between the glomerular filtration in the transplanted and intact kidneys. It is clear from Table 2 that the coefficient of inulin clearance, even in the period before the convulsion, was

TABLE 2. Changes in the Coefficient of Inulin Clearance and the Inulin Concentration Index After Convulsions in the Dogs Ugryum and Bobik After Coagulation of the Medulla of the Left Adrenal and Removal of the Right Adrenal

Index of kidney function	Statistical index	Before convulsion		After convulsion (15 min)	
		Transplanted kidney	Intact kidney	Transplanted kidney	Intact kidney
Coefficient of inulin clearance (in ml/min/m²)	M ± m	50.55 ± 5.76	42.78 ± 1.46	27.20 ± 3.21	7.00 ± 2.29
Inulin concentration index	M ± m	13.32 ± 2.46	16.72 ± 4.85	102.77 ± 19.06	105.01 ± 13.12

higher for the transplanted kidney than for the intact ($P < 0.05$), while in the period after the convulsion this difference was even clearer ($P < 0.01$), whereas in the dogs with intact adrenals the autotransplanted kidney reacted to the convulsion by a change in filtration similar to that of the intact kidney. The changes in the inulin concentration index were similar for both kidneys.

Meanwhile exclusion of the medulla of both adrenals did not completely abolish the reactions of the autotransplanted kidney to the convulsion, while the kidney with the intact innervation reacted in the same way as before the operation on the adrenals. Possibly the prevention of entry of adrenalin from the adrenals into the blood stream during the convulsion was compensated to some extent by the secretion of adrenalin-like substances from other collections of chromaffin tissue in the body [7].

It may be concluded from the results of this investigation that denervation of the kidney has no significant effect on the character of the changes in its functions in response to convulsions. Only when the entry of adrenalin from the adrenals into the blood stream is prevented can more obvious differences be observed in the changes in function of the glomerular apparatus of the autotransplanted and intact kidneys. However, neither denervation nor exclusion of the adrenal medulla could completely prevent changes in the kidney functions.

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