CHANGES IN THE EXCRETION OF URINE FOLLOWING INJECTION OF POTASSIUM CYANIDE INTO THE RENAL ARTERY

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In experiments on kidney slices cyanides disturb the secretory processes in the kidney [2, 3]. These changes in kidney function are evidently associated with disturbances of metabolism in the kidney tissue, because cyanide, by blocking electron transfer in the cytochrome system, disturbs tissue respiration.

Following intravenous injection of cyanides in small doses, a decrease in diuresis takes place, due to reflex (resulting from stimulation of the carotid sinuses) liberation of pituitary antidiuretic hormone [1].

To avoid this indirect effect of cyanides on diuresis, in the present investigation the preparation was injected into one of the renal arteries, and a number of indices of kidney function were studied.

EXPERIMENTAL METHOD

A lateral incision was made in a dog anesthetized with hexobarbital, one of the renal arteries (usually the left) was exposed, and a fine needle was introduced into it. This needle was connected to a vessel containing isotonic sodium chloride solution, which was injected into the artery continuously at a speed of 0.5-1.5 ml/min. Periodically during the experiment, instead of the isotonic solution, a solution of potassium cyanide of varied concentration was injected for 10-95 min. The dogs received physiological saline intravenously to maintain a constant background of diuresis. The urine was collected separately from each kidney by means of polyvinyl chloride catheters introduced through an incision in the ureter as far as the pelvis.

The volume of urine, the concentration of sodium and potassium in the urine and plasma (by the flame photometry method), the filtration by means of endogenous creatinine or inulin, and the urinary chloride (by Volhard's method), were determined. The clearance coefficients were calculated by the usual formula. Altogether 30 infusions were given to 10 animals.

EXPERIMENTAL RESULTS

Injection of potassium cyanide into the renal artery in a dose of 16-222 μg/kg/min was always accompanied by a sharp increase in the diuresis to a level 2-20 times higher than initially.

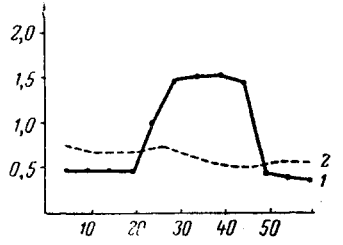

Fig. 1. Effect of intra-arterial injection of potassium cyanide (16 μg/kg /min) on diuresis. Along the axis of abscissas—time (in min), along the axis of ordinates—diuresis (in ml), 1) diuresis from the left kidney, 2) diuresis from the right (control) kidney; arrows—beginning and end of injection of KCN into the left renal artery. Experiments, May 10, 1963.

It is clear from Fig. 1 that the increase in diuresis in the left kidney began soon after injection of potassium cyanide into its artery, and after 10-15 min it reached its maximum. The diuresis returned to normal or actually fell below the initial level 10-15 min after the infusion ended. The diuresis from the opposite kidney, acting as control, remained unchanged during the experiment, demonstrating the direct action of potassium cyanide on the tissue of the investigated kidney.

The increase in diuresis was proportional to the dose of cyanide. In one experiment, for instance, for infusion of 25 μg/kg/min the minute volume of diuresis rose from 1.3 to 1.7 ml, an increase in the dose of cyanide to 33 μg/kg/min caused an increase to 2.7 ml, while doses of 43 and 86 μg/kg/min led to increases of up to 3.3 and 5.2 ml respectively. With the last two doses of cyanide, the diuresis in the opposite kidney began to fall, and this decrease was particularly noticeable when a dose of 86 μg/kg/min was injected. This oliguria in the control kidney was evidently associated with entry of the cyanide into the general circulation.

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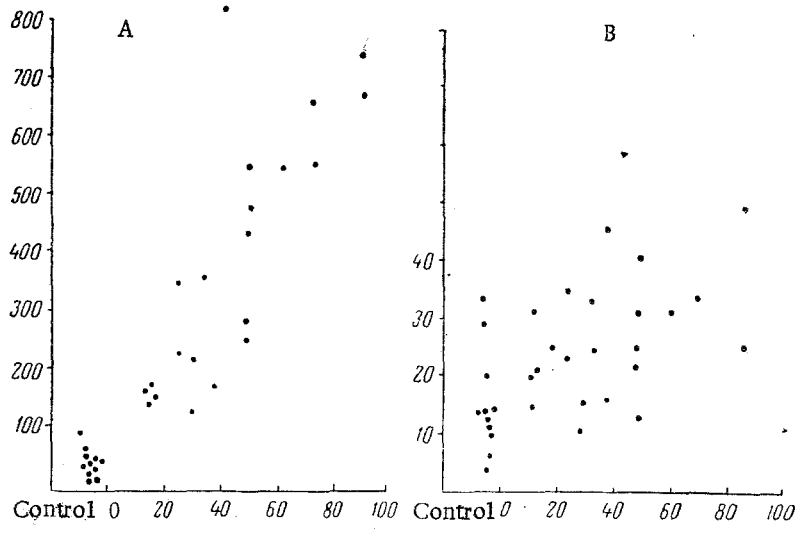

Fig. 2. Excretion of sodium and potassium ions under the influence of various doses of potassium cyanide. Along the axis of abscissas—dose of cyanide (in μg/kg/min), along the axis of ordinates—excretion of Na^+ or K^+ (in μeq/min); the points denote the result of individual experiments; A—excretion of Na^+; B—excretion of K^+.

Effect of Potassium Cyanide on Diuresis, Excretion of Electrolytes, and Creatinine Clearance (mean results of 22 infusions in 6 dogs)

Statistical index	Diuresis (in ml/min		Excretion of Na^+ (in μeq/min)		Excretion of K^+ (in μeq/min)		Creatinine clearance (in ml/min)	
	control	KCN	control	KCN	control	KCN	control	KCN
$M \pm m$	0,86±0,21	3,48 0,67	41±21,5	376 104	14,4 0,91	22,6 2,8	15,7 2,48	12,3 3,52
P	<0,01		<0,01		<0,05		<0,5	

After injection of cyanide the glomerular filtration fluctuated between 60 and 120% of the initial level, but in most experiments it fell slightly (by 10-15%). Consequently, the changes in diuresis were associated mainly with a decrease in reabsorption in the renal tubules.

The results of investigation of the urinary electrolytes showed that under the influence of cyanides the excretion of sodium ions rose sharply—to 3-30 times the initial level. The level of sodium excretion depended on the dose of cyanide. The results of 22 injections given to 6 dogs are illustrated in Fig. 2A. As this figure shows, in the control (before injection of the cyanide) as a rule the sodium excretion was less than 100 μeq/min, and after a dose of 20-40 μg/kg min it rose to 400-800 μeq/min or more. The increase in the sodium excretion under the influence of cyanide preceded the increase in diuresis slightly. The results of 22 infusions given to 6 animals are shown in the table. These results show that under the influence of cyanide the diuresis increased less than the sodium excretion. It may, therefore, be postulated that the increase in diuresis was a secondary phenomenon, caused by the increase in the loss of sodium ions.

However, the doses of cyanide studied did not completely suppress the reabsorption of sodium in the kidneys. For instance, in an experiment on January 17, 1964 (it was in this experiment that the excretion of sodium showed the greatest increase— to 1248 μeq/min), at the time of maximal development of the effect of cyanide, the sodium clearance was 8.8 ml/min and the filtration, as shown by inulin, 28.6 ml/min; consequently, the excretion of sodium was only 31% of the sodium filtered in the renal glomeruli.

Under the influence of cyanide, the excretion of chloride ions also increased; this increase took place parallell to the increase in the excretion of sodium ions.

Potassium cyanide modified the excretion of potassium ions. As Fig. 2B shows, the excretion of potassium with all tested doses of cyanide increased by almost the same amount—by 50-200%, and it was usually 24-40 μeq/min (before injection of cyanide it was 10-15 μeq/min). The potassium clearance rose from 5.5±0.12 to 7.4±0.55 ml/min; the difference is statistically significant ($P < 0.01$). The ratio between the potassium clearance and the creatinine clearance before injection of cyanide was 0.23-0.55, and after injection 0.72-1.65. The increase in the excretion of potassium was possibly due to depression of the reabsorption of this ion by cyanide.

The disturbance of respiration in the kidney tissue by injection of potassium cyanide into the renal artery was thus accompanied by a sharp increase in diuresis and an even greater increase in sodium excretion. This fact confirms the views of investigators that the main energy of the oxidative processes in the kidney is used to produce reabsorption of sodium in the renal tubules [4-7]. The results of these experiments agree with those obtained by Stricker and Kessler [8], who observed an increase in diuresis and sodium excretion following injection of 0.077-0.14 mmole sodium cyanide into the renal artery of dogs.

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