EFFECT OF EFFERENT INNERVATION ON KIDNEY FUNCTION

M. I. Mavrin

UDC 612.46-06:612.916

Unilateral stimulation of the peripheral and of the splanchnic nerve induces a decrease in diuresis, filtration, and secretion in the kidney on the side of stimulation and a decrease in the plasma flow in both kidneys. The splanchnic nerves provide a crossed sympathetic innervation to the vascular system of the kidneys. Stimulation of the peripheral end of the right vagus nerve below the diaphragm leads to an increase in diuresis, filtration, plasma flow, and secretion in both kidneys. Stimulation of the left vagus nerve had no effect on tubular activity.

According to some observations [5, 9], the splanchnic and vagus nerves affect only the glomerular system of the kidneys, although other workers observed changes in the activity of the renal tubules [1, 2] while others found no such changes [6].

The object of the present investigation was to examine the influence of the splanchnic and vagus nerves on kidney function.

EXPERIMENTAL METHOD

Chronic experiments were carried out on dogs with the ureters exteriorized separately. Filtration was determined relative to inulin, and the plasma flow and secretion relative to cardiotrast [4]. During the period of the experiment a 0.6-0.7% solution of inulin and a 1% solution (for measuring the blood flow) or 6-7% solution (for measuring secretion) of cardiotrast were injected intravenously at the rate of 0.5 mg/kg per minute for cardiotrast (when measuring the blood flow), and 5-7 mg/kg per minute for cardiotrast when measuring secretion [2]. The excretion of inulin and cardiotrast was calculated by the method of Goldring et al. [7]. The blood inulin level was determined by Schreiner's method [8], and the cardiotrast level by the method of White and Rolf [10]. Blood samples were taken in the middle of the period of urine collection. The splanchnic and vagus nerves were stimulated by means of an electronic pulse stimulator (ISE-01; frequency 10-20 pulses/sec, pulse duration 1-2 msec, voltage 3-10 V). The nerves were stimulated on the second to 7th days after insertion of the electrodes [2].

Altogether 105 chronic experiments were carried out on 19 animals.

EXPERIMENTAL RESULTS

In experiments on 11 dogs stimulation of the peripheral end of the splanchnic nerve was accompanied by inhibition of diuresis in the kidney on the side of stimulation by 40%, of filtration by 26%, of the plasma flow by 38%, and of secretion by 27-53% (Table 1). The increase of 26% in the inulin concentration index was evidence of increased reabsorption of water in the distal tubules. The lowering of the hemodynamic indices was the result of cortical ischemia of the kidney. The low values of secretion indicate the direct action of the sympathetic fibers on the proximal tubules. The decrease of 22% in the plasma flow in the control (contralateral) kidney while the rate of filtration was unchanged was due to the action of

Department of Normal Physiology and Faculty of Surgery, S. V. Kurashov Kazan' Medical Institute.
(Presented by Academician of the Academy of Medical Sciences of the USSR A. A. Vishnevskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 75, No. 4, pp. 15-17, April, 1973. Original article submitted February 28, 1972.

TABLE 1. Effect of Stimulation of Peripheral End of Splanchnic Nerve on Kidney Function in 11 Dogs (M ± m)

Index of kidney function	Kidney	Before stimulation	After stimulation		
			5 min	15 min	25 min
Diuresis (in ml/min)	S	2,95±0,28	1,76±0,18 ($P<0.01$)	2,91±0,51	2,77±0,31
	C	2,90±0,25	2,87±0,22	2,89±0,43	2,70±0,04
Inulin concentration index	S	10,2±0,84	12,9±0,86 ($P<0,05$)	11,1±1,22	12,0±1,19
	C	10,3±0,81	10,6±0,82	12,3±0,82	11,6±1,13
Filtration (in ml/min·m^2)	S	43±0,53	32±1,54 ($P<0,001$)	42±1,70	43±1,72
	C	43±1,80	44±2,84	44±2,58	44±2,08
Plasma flow (in ml/min·m^2)	S	183±4,06	114±7,42 ($P<0,001$)	177±3,33	173±6,54
	C	182±3,83	141±9,18 ($P<0,001$)	183±4,45	183±3,88
Secretion (in mg/min·m^2)	S	13,1±0,60	6,2±0,40 ($P<0,001$)	9,5±1,09 ($P<0,02$)	10,6±1,45
	C	13,0±0,58	13,7±1,34	11,7±1,30	10,5±0,92

TABLE 2. Effect of Stimulation of Peripheral End of Right Vagus Nerve Below the Diaphragm on Kidney Function in 5 Dogs (M ± m)

Index of kidney function	Kidney	Before stimulation	After stimulation		
			5 min	10 min	15 min
Diuresis (in ml/min)	S	2,32±0,29	3,40±0,23 ($P<0,02$)	2,32±0,33	2,01±0,20
	C	2,54±0,51	3,23±0,69	2,41±0,39	2,08±0,29
Inulin concentration index	S	12,4±2,29	10,6±1,43	12,4±1,78	13,1±1,76
	C	11,4±2,21	10,2±1,64	11,7±1,77	13,4±1,78
Filtration (in ml/min·m^2)	S	40±0,63	52±0,63 ($P<0,001$)	42±2,15	39,0±0,91
	C	40±1,12	49±2,64 ($P<0,01$)	42±0,46	41±0,74
Plasma flow (in ml/min·m^2)	S	178±1,16	226±6,80 ($P<0,001$)	182±0,61	176±4,87
	C	181±6,81	220±5,69 ($P<0,01$)	175±6,20	181±4,15
Secretion (in mg/min·m^2)	S	11,7±1,17	16,5±0,94 ($P<0,02$)	14,0±1,20	12,9±0,76
	C	12,1±0,93	16,2±1,48 ($P<0,05$)	12,7±0,81	12,5±0,53

vasoconstrictor fibers of the splanchnic nerve, which also cross to the opposite side through the ganglia of the solar plexus [3]. Disturbances of the plasma flow in both kidneys during unilateral stimulation of the splanchnic nerve are evidence of the crossed sympathetic innervation of the renal blood vessels.

In experiments on five animals stimulation of the peripheral end of the right vagus nerve below the diaphragm led to an increase in diuresis by 27-46%, filtration by 22-30%, plasma flow by 21-27%, and secretion by 34-41% in both kidneys, mainly on the side of stimulation (Table 2). The response of both kidneys was evidently due to the crossed innervation of the glomerularand tubular portions of the nephrons by the right vagus nerve.

Stimulation of the peripheral end of the left vagus nerve below the diaphragm in experiments on 3 animals reduced the plasma flow in both kidneys by 30-45% (evidently because of the large numer of sympathetic fibers contained in it) but without changing the rate of diuresis, reabsorption, filtration, and secretion.

Unilateral stimulation of the peripheral end of the splanchnic nerve is thus accompanied by a decrease in the plasma flow in both kidneys, evidently brought about by the crossed sympathetic innervation of the renal vascular system. Stimulation of the splanchnic nerve also inhibits diuresis, filtration, and secretion in the kidney on the side of stimulation. Stimulation of the right vagus nerve below the diaphragm causes an increase in diuresis, filtration, plasma flow, and secretion in both kidneys, while stimulation of the left vagus nerve below the diaphragm has no effect on tubular activity.

LITERATURE CITED

1. A. G. Ginetsinskii, V. F. Vasil'eva, M. G. Zaks, et al., in: Problems in the Evolution of Physiological Functions [in Russian], Moscow–Leningrad (1958), p. 17.

2. V. F. Lysov, Byull. Éksperim. Biol. i Med., No. 7, 29 (1968).
3. M. I. Mavrin, Éksperim. Khir., No. 1, 42 (1962).
4. I. A. Nikolaevich, Byull. Éksperim. Biol. i Med., No. 5, 59 (1960).
5. K. Aukland, Acta Physiol. Scand., 72, 498 (1968).
6. J. Concha and B. Narris, Brit. J. Pharmacol., 34, 277 (1968).
7. W. Goldring, H. Chasis, H. A. Ranges, et al., J. Clin. Invest., 20, 637 (1941).
8. G. E. Schreiner, Proc. Soc. Exp. Biol. (New York), 74, 117 (1950).
9. A. J. Vander, Am. J. Physiol., 209, 659 (1965).
10. H. White and D. Rolf, Proc. Soc. Exp. Biol. (New York), 43, 1 (1940).