REFLEX INFLUENCE OF THE PRESSURE RECEPTORS OF THE STOMACH ON THE RENAL CIRCULATION IN NORMAL CONDITIONS AND EXPERIMENTAL RENAL HYPERTENSION

A. I. Vyshatina

Laboratory of the Physiology of the Circulation of the Blood and Respiration (Director — Active Member AMN SSSR N. N. Gorev) of the A.A. Bogomol'ts Institute of Physiology (Director — Corresponding Member AN Ukr.SSR Prof. A. F. Makarchenko) of the AN Ukr.SSR, Kiev
(Presented by Active Member AMN SSSR N. N. Gorev)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny
Vol. 49, No. 5, pp. 36-41, May, 1960
Original article submitted May 15, 1959

In recent years the mechanism of regulation of the regional circulation of the blood has occupied the attention of researchers on an increasing scale. Work recently published has shown that reflex changes in the level of the arterial blood pressure, of different origin, may be based upon changes of vascular tone in various regions of the body, revealed in different ways and in different combinations. A. M. Blinova, G. N. Aronova, and K. E. Serebryanik [1] observed dissimilar changes in the tone of the vessels of the kidneys, intestine and limbs in the course of pressor reactions as a result of stimulation of the thalamic region, compression of both common carotid arteries and the injection of promethine. From specially carried out investigations, these authors conclude that the distinctive reactions of different vascular fields in the mechanism of the pressor reactions under investigation are due to changes in the functional state of the vasomotor center. V. M. Khayutin [8] found that the reactions of the renal vessels are dependent on the character of the stimulation; they are more pronounced in response to stimulation from the interoceptors of the large intestine, and decrease in the order : urinary bladder, tibial nerve, carotid sinus.

By investigating the electrical activity of the preganglionic branches of the sympathetic nervous system (cervical and splanchnic nerves), N. K. Saradzhev [7] concludes that the spread of excitation from the vasomotor center during the pressor reactions under test to the mechanoreceptors of the urinary bladder and carotid sinuses is not the same. T. S. Lagutina [6], also by electrophysiological methods, investigated the relationship between the reflexes proper and the stretch reflexes developing during increasing intensity of stimulation of the mechanoreceptors of the urinary bladder.

The object of the present investigation was to study the changes in the renal circulation under the influence of "stretch" reflexes from the pressure receptors of the stomach, and to compare these with the results previously obtained on the character of the reactions of the renal vessels to reflex influences from other interoceptive fields [2]. It was also very interesting to discover whether there is any difference in their reactions when the vascular tone is pathologically changed during experimental renal hypertension. According to V. N. Chernigovskii, in the case of "stretch" reflexes, other physiological systems besides that with which the particular interoceptive zone is connected are involved in the reaction.

The present work is the continuation of investigations conducted over a period of several years in our laboratory on the role of the renal pressor factor in the regulation of the level of the blood pressure in normal conditions and in experimental hypertension.

EXPERIMENTAL METHOD

The animals were investigated on an empty stomach. In the first place, they were given a high water intake: rabbits received 40 cm^3 water per kg body weight by gastric tube, dogs, 600-800 cm^3 milk, diluted with water. Anesthesia was by intravenous injection of nembutal (40 mg/kg body weight). The renal circulation was investigated by Rein's thermoelectric method. The thermoelements were applied transperitoneally to the renal artery (or one of its branches) and to the renal vein to check the inflow and outflow of blood from the kidneys. The operation wound was carefully sutured in layers. At the same time, the changes in the level of the blood pressure in the femoral artery were recorded on a mirror galvanometer by means of a photocell. The pressure receptors of the stomach were stimulated by distension of a thin rubber balloon, introduced into the stomach by means of a tube (50-100 cm^3 of air in the case of rabbits, and 200-600 cm^3 of air in dogs). At the beginning of the experiment less intensive stimuli were usually used, and then a change was made to more intensive. Stimulation lasted for 2-2.5 min. The intervals between the periods of stimulation were not less than 15-20 min. Experimental renal hypertension was induced by the routine method used in our laboratory. The animals were investigated in the 2nd-4th month of development of hypertension. In all, 37 experiments

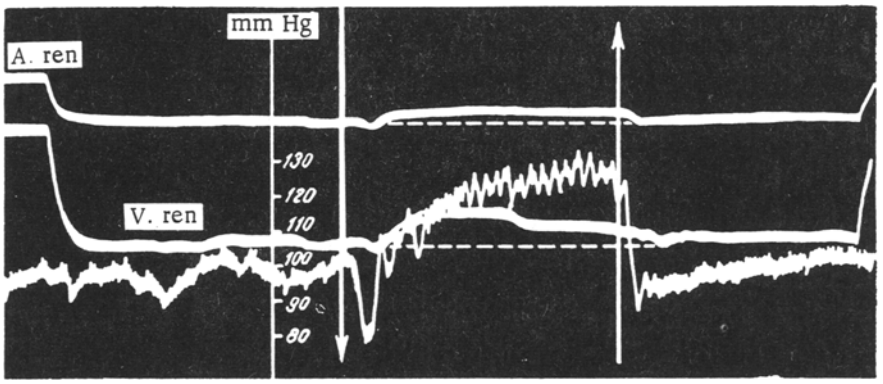

Fig. 1. Increase in the renal blood flow simultaneously with an increase in the blood pressure during inflation of a rubber balloon in the stomach with 100 cm^3 of air (experiment on a rabbit). Significance of the curves (from above, down): blood flow in the renal artery , the same in the renal vein, blood pressure in the femoral artery; ↓ ↑) markers of the beginning and end of stimulation.

were performed; 19 of these were carried out on normal animals (13 rabbits and 6 dogs) and 18 on animals with hypertension (10 rabbits and 8 dogs). In the experiments on animals with hypertension, the inflow of blood to the kidneys was investigated in the pulsating segment of the renal artery distal to the clamp (in experiments on dogs the thermoelement was usually applied to one of the branches of the renal artery).

EXPERIMENTAL RESULTS

Comparison of the reactions of the renal vessels to stimulation from the various interoceptive areas in normal animals shows that their reaction to stimulation from the interoceptors of the internal organs varies much more than that to pressor influences from the pressure receptors of the carotid sinuses [2]. In a given case this is shown by the fact that, along with passive changes in the renal blood flow, active changes are also found in the tone of the renal vessels. The passive changes in the renal blood flow are expressed as changes in the blood flow in the renal artery and vein, occurring at the same time and in the same direction as the level of the blood pressure. By way of example of the passive influence of the raised blood pressure, under the influence of stimulation of the pressure receptors of the stomach, on the renal circulation, we give the results of one such experiment in Fig. 1. Increase in the blood pressure by inflation of the balloon by introduction of 100 cm^3 of air was accompanied in this experiment by a simultaneous increase in the blood flow in the renal vessels (experiment on a rabbit).

Active changes in the tone of the renal vessels—their dilation or constriction—may be judged by changes in different directions in the blood flow in the renal vessels and the level of the blood pressure [11-14 and others]. With dilatation of the renal vessels there is a fall in the blood flow in the renal vein, whereas the blood flow in the artery remains at the same level or may even be increased. The impression was created that, at a given moment, the inflow of blood exceeded the outflow, which was naturally only possible by an increase in the capacity of the blood vessels. Constriction of the renal vessels was demonstrated by the converse changes, namely, a fall in the blood flow in the renal artery and an unchanged, or even increased blood flow, especially at the beginning of stimulation, in the renal vein.

Of the 19 experiments carried out on normal animals in 10 (8 experiments on rabbits and 2 on dogs) the renal circulation was either unchanged or changed in a passive manner; in the remaining nine experiments an active reaction of the renal vessels was observed, and in particular in five experiments (on four rabbits and one dog), in the form of dilatation, and in four (one experiment on a rabbit and three on dogs) in the form of constriction of the renal vessels. In Fig. 2 are shown the results of one of the experiments, in which active changes in the tone of the renal vessels were observed in response to reflex influences from the pressure receptors of the stomach, in the form of dilatation.

The increase in the blood pressure as a result of inflation of the balloon in the stomach with 100 cm^3 of air was accompanied by a well-marked increase in the blood flow in the renal artery and a fall in the blood flow in the renal vein: evidence of dilatation of the vessels within the kidney. The changes described above in the blood flow in the renal artery and vein, reflecting active changes in the tone of the vessels within the kidney , may be extremely variously manifested; it may be gathered from this how different in their course the reactions of the vessels may be.

When stimulation of different intensities was used in the same experiment, the more intensive stimulation was accompanied usually by the more pronounced changes in the renal circulation; in some cases an active reaction of the vessels was observed.

The development of experimental renal hypertension was associated with the appearance of reactions of varying

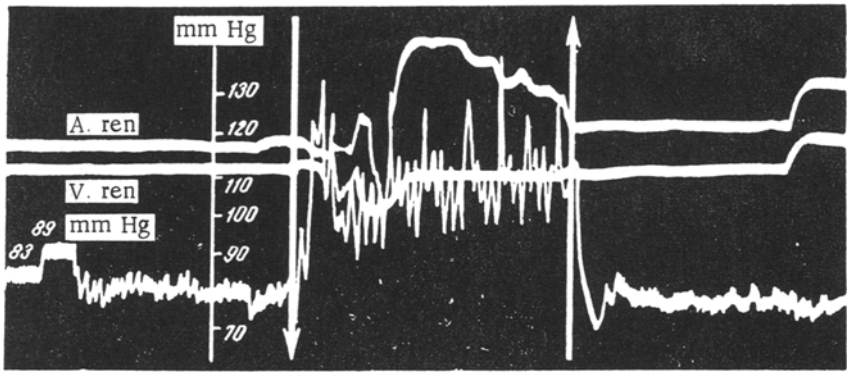

Fig. 2. Dilation of the renal vessels during inflation of a balloon in the stomach by introduction of 100 cm³ of air (experiment on a rabbit). Legend as in Fig. 1.

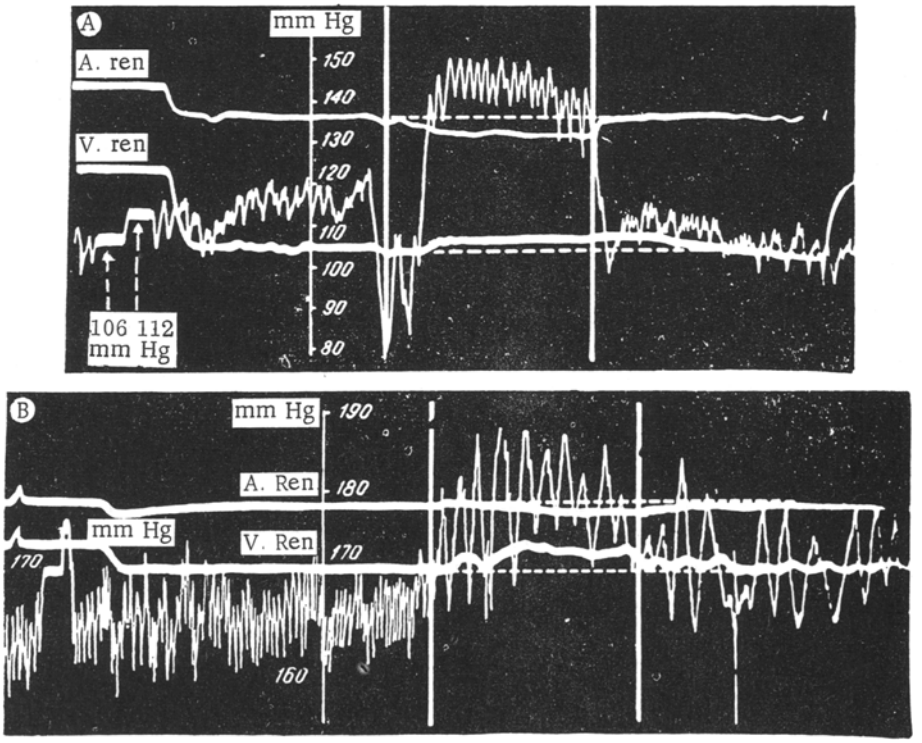

Fig. 3. Spasm of the renal vessels in response to reflex influences from the stomach in the presence of experimental renal hypertension. A) Experiment on a rabbit (inflation of the balloon in the stomach with 100 cm³ of air); B) experiment on a dog (inflation of the balloon in the stomach with 200 cm³ of air). Legend as in Fig. 1.

character in the renal vessels in response to reflex influences from the stomach. In contrast to normal animals, those with hypertension showed a clear tendency toward predominantly active reaction of the renal vessels in response to these influences in the form of spasm. When hypertension was present, this type of reaction in response to different forms of stimulation became so predominant that it was even impossible to detect any difference in the reaction of the renal vessels to stimulation from the stomach and from the carotid sinuses. Of 18 experiments performed on animals with experimental renal hypertension, spasm of the renal vessels in response to distension of the stomach was observed in 16 (9 on rabbits and 7 on dogs). In the remaining experiments dilatation of the renal vessels was found (one experiment on a rabbit and one on a dog).

Figure 3 shows the results of two experiments on animals with hypertension. We may see that stimulation of the pressure receptors of the stomach led to a fall in the blood flow in the renal artery and an increase in the blood flow in the renal vein, thus demonstrating constriction of the vessels within the kidney. At the end of stimulation the tone of the renal vessels returned to its original state, as shown by the restoration of the inflow of blood to and outflow from the kidneys.

It should be mentioned that the tendency toward spasm of the renal vessels in response to reflex influences

from the stomach was especially pronounced when the stimulation was very intensive. This distinctive character of the reaction of the renal vessels shows that, during hypertension, the renal pressor factor may participate in the mechanism of the interoceptive pressor reflexes, possibly acting as one of the humoral factors responsible for the degree and duration of these reflexes. It is brought into play reflexly, as the result of appropriate interoceptive influences.

Investigations carried out in recent years into the etiopathogenesis of the hypertensive state, both experimental and clinical, in the light of the views of Soviet scientists on the neurogenic nature of hypertension, have shown that the initial stages of hypertension are characterized by a high level of excitation of the higher divisions of the central nervous system and of the central apparatus regulating the circulation of the blood (G. F. Lang, A. L. Myasnikov, A. K. Dolin, S. D. Kaminskii, and V. I. Savchuk, N. N. Gorev, and M. I. Gurevich, and others). Changes in the functional state of the central nervous system with the appareance of increased excitation of the vasomotor apparatus are also clearly seen in animals with experimental renal hypertension [3-5, 10].

The difference observed in the present investigation between the reactions of the renal vessels in animals with hypertension and those in normal animals was evidently due to changes in the functional state of the central apparatus of regulation of the circulation of the blood.

SUMMARY

In normal animals, variations of reactions of the renal vessels to the reflex effect from the stomach are greater than their reactions in response to the effects from the carotid sinuses. In about 50 % of the experiments , the changes of the renal circulation were characterized by active changes of the renal vessel tone in the form of dilatation and constriction. Development of experimental renal hypertension is associated with the reaction of the renal vessels (mainly spastic in character) to the pressor effects from the stomach. Consequently, reflex effects from the stomach may occasion the functional inclusion of the renal pressor factor in the mechanism of pressor reactions in hypertension. The development of experimental renal hypertension is characterized by the increased excitability of the central circulatory control apparatuses. The distinction between the reactions of the renal vessels in animals with hypertension and those in normal animals may be explained by the difference in the intial functional condition of the vasomotor centers, against the background of which the stimulation is effected.

LITERATURE CITED

1. A. M. Blinova, G. N. Aronova, and K. E. Serebryanik, The Nervous Control of the Circulation of the Blood and of Respiration [in Russian] (Moscow, 1952), p. 211.
2. A. I. Vishatina, Fiziol. Zhur. Ukrain. 5, 75 (1959).
3. N. N. Gorev, Hypertension Studies [in Russian] (Kiev, 1959).
4. M. I. Gurevich, Fiziol. Zhur. Ukrain. 1, 62 (1955).
5. M. A. Kondratovich, Voprosy Fiziol. No. 7, 105 (1954).
6. T. S. Lagutina, Byull. Eksp. Biol. Med. No. 1, 3 (1959).*
7. N. K. Saradzhev, Fiziol. Zhur. SSSR 45, 65 (1959).
8. V. M. Khayutin, Byull. Éksp. Biol. Med. No. 10, 18 (1958).*
9. L. P. Cherkasskii, Voprosy Fiziol. No. 10, 107 (1954).
10. V. N. Chernigovskii, Zhur. Vysshei Nerv. Deyatel. 6, 53 (1956).
11. P. Eckardt, Arch. ges. Physiol. 236, 361 (1935).
12. T. Gotsev, Arch. ges. Physiol. 236, 220 (1935).
13. H. Rein, R. Liebermeister, and D. Schneider, Klim. Wschr. 11, 1636 (1932).
14. H. Schweiegk, and S. Pfluger, Arch. ges. Physiol. 236, 206 (1935).

* Original Russian pagination. See C.B. Translation.