PECULIARITIES OF THE PERIPHERAL AND RENAL VASCULAR REACTIONS TO INTEROCEPTIVE STIMULATIONS UNDER NORMAL CONDITIONS AND IN RENAL HYPERTENSION

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Available data in the literature attest to the fact that changes in the level of general arterial pressure may consist of various, as to their expressiveness and direction, regional vascular reactions [1,11,13,15,16,17].

The study of the peculiarities of correlation between the level of general arterial pressure and regional circulation under conditions of a pathologically altered vascular tonus, namely in hypertension, is of definite interest.

In our previous reports [3,4] we pointed out that, under conditions of experimental chronic hypertension, the character of reactions of renal vessels undergoes certain changes. In animals with hypertension the pressor reflexes from various interoceptive zones are accompanied mainly by an active reaction of the renal vessels in the form of constriction.

In the present work we carried out a comparative investigation of the reactions of peripheral and renal vessels to interoceptive stimuli from the baroreceptors of the sinocarotid zones and internal organs (stomach, small intestine, lungs) in healthy animals and in animals with experimental hypertension.

METHOD

Investigation of the regional vascular reactions was carried out via photorecording of the qualitative changes of the volume rate of the inflowing and outflowing blood of an organ, by employing the Rein thermoelectric method.

The animals (rabbits and dogs) were narcotized via intravenous administration of nembutal, at a 40 mg dose per kg weight. For the investigation of renal circulation the thermoelements were applied to the renal artery (or its branch) and vein; for peripheral circulation — to the femoral artery and vein in the upper third of the femur with subsequent layer-by-layer suturing of the incisions.

Changes in the level of general arterial pressure were recorded on the femoral artery of the opposite side with a mirror galvanometer by means of a photocell transmitter.

The pressor reflex from baroreceptors of the sinocarotid zones was induced by compressing the trunks of both common carotid arteries. Stimulation of the mechanoreceptors of the stomach was produced by inflating via gastric sound a thin-walled rubber balloon with air (50-100 cm^3 of air in rabbits and 200-600 cm^3 of air in dogs); the mechanoreceptors of the small intestines were stimulatied by inflating an isolated segment of the intestines, 15-25 cm to 20-40-60 mm of mercury column.

The depressor reflex from the lungs was induced by inflating the respiratory pathways of the lungs in rabbits to 100-150 mm of water column, in dogs to 10-20 mm of mercury column. At the start of the experiment we generally used less intense stimuli and later changed to more intense ones. Intervals between stimuli constituted at least 15-20 minutes.

Experimental renal hypertension was induced by the method suggested by N. N. Gorev [5]. The animals were examined on the 2nd-3rd month of the development of hypertension, i.e., during the period of the highest rise of blood pressure. In the experiments with hypertensive animals the inflow of blood to the kidneys was measured in the pulsating segment of the renal artery distal from the applied ring (in experiments on dogs the thermoelement was usually applied to one of the branches of the renal artery).

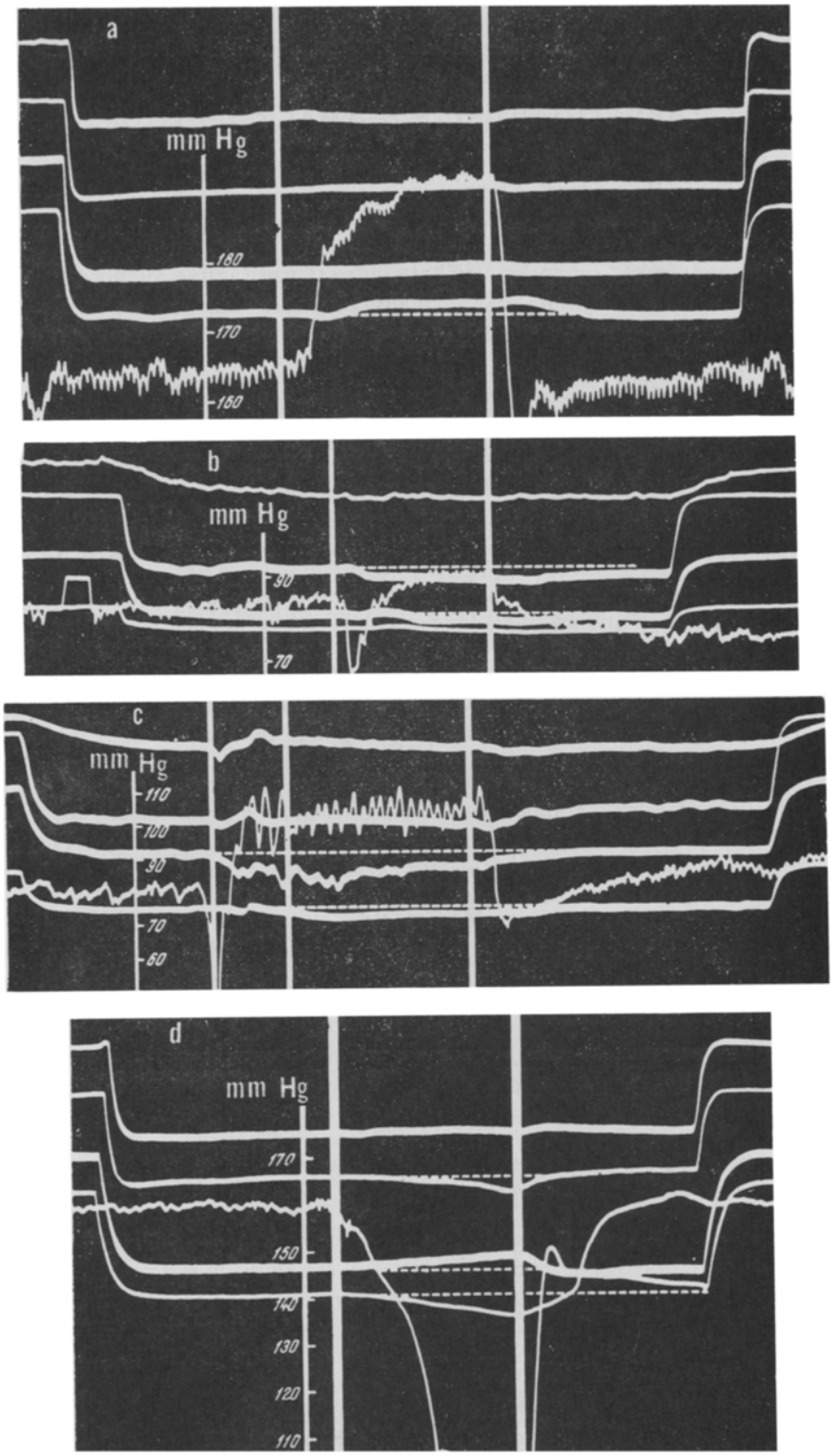

Fig. 1. Reaction of the peripheral and renal vessels to the interoreceptive stimulations in healthy animals. a) from baroreceptors of the sinocarotid region (experiment on a dog); b) from baroreceptors of the small intestine (experiment on a rabbit); c) from the gastric baroreceptors (experiment on a rabbit); d) from pulmonary baroreceptors (experiment on a dog). Meaning of curves from top downward: blood flow in the renal artery, renal vein, femoral artery, femoral vein, arterial blood pressure in the femoral artery. Vertical black lines — the beginning and end of stimulation.

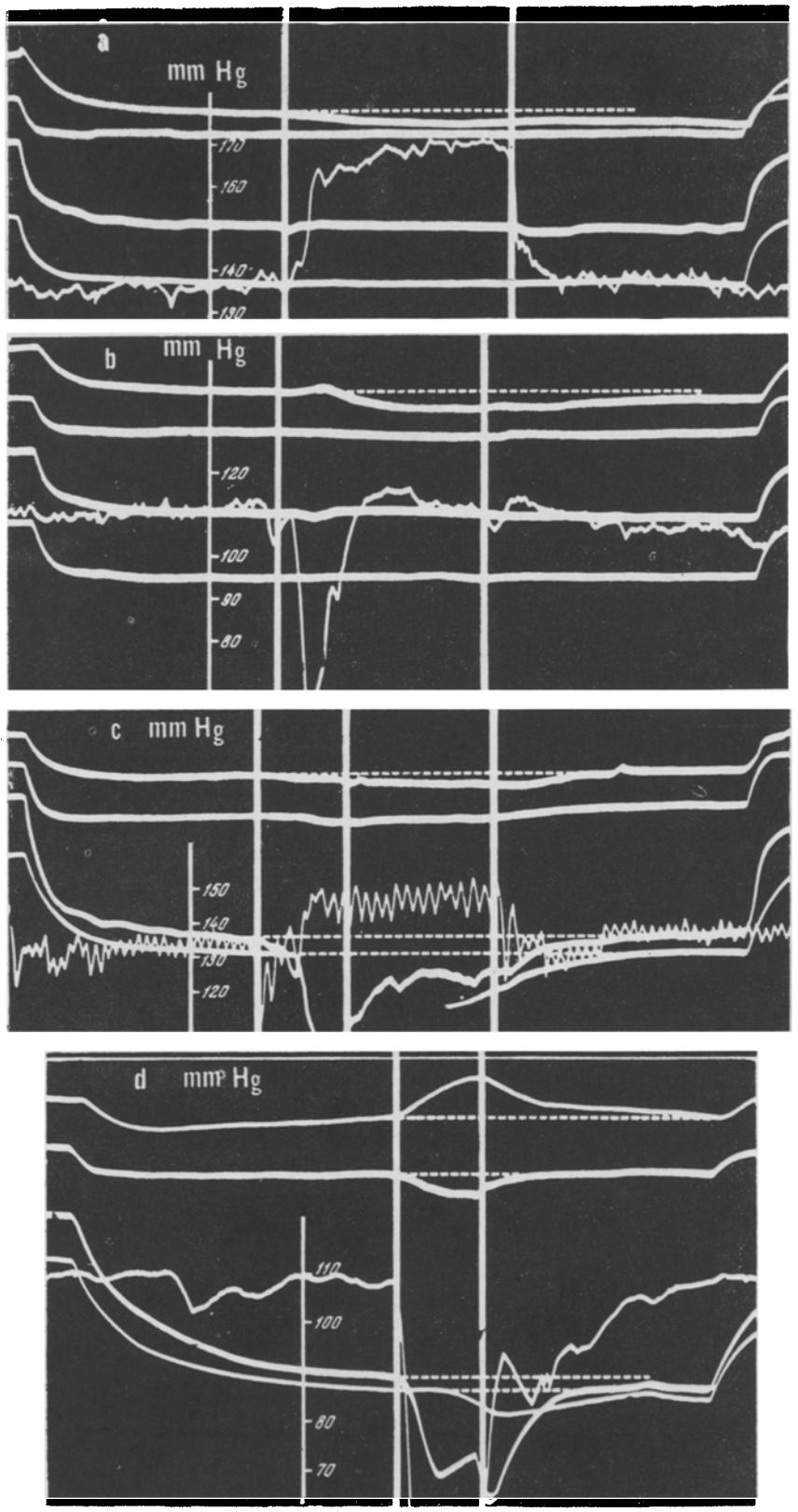

Fig. 2. Reaction of the peripheral and renal vessels to the interoreceptive stimuli in hypertensive animals. a) from baroreceptors of the sinocarotid region (experiment on a rabbit); b) from baroreceptors of the small intestine (experiment on a rabbit); c) from baroreceptors of the stomach (experiment on rabbit); d) from pulmonary baroreceptors (experiment on rabbit). Meaning of curves: the same as in Fig. 1.

The work was carried out on 32 healthy animals (eight dogs and 24 rabbits) and 22 hypertensive animals (10 dogs and 12 rabbits).

RESULTS

The characteristic course of each of the investigated interoceptive reflexes can be observed in healthy animals. The pressor reflexes under usual conditions are induced by the constriction of peripheral vessels, while depressor reflexes react to the dilatation of these vessels.

The intensity and direction of the renal vascular reactions differed in accordance with the applied interoreceptive stimulation. Thus, the pressor reflex from baroreceptors of the sinocarotid zones took place upon constriction of the peripheral vessels, whereas renal circulation showed no change, as had been pointed out back in 1936 by Hartman, Orskov, and Rein [18]. Fig. 1 a shows the photorecording of one of the experiments in the study of reflex influences from baroreceptors of the sinocarotid zones on renal and peripheral circulation.

As seen in Fig. 1 a the rise in blood pressure is accompanied by a constriction of the peripheral vessels which is manifested in the increased venous outflow from the extremity; the renal circulation is not affected. It should be noted that the peripheral vascular constriction following reflex influences from the carotid sinuses, according to our data, is quite frequently manifested in the increase of the venous outflow from the extremity, whereas in the femoral artery the blood flow is not affected. Of the 16 experiments conducted in the study of the sinocarotid reflex, the above described regional reactions took place in 15 experiments, and only in one there was an increased flow observed in the femoral artery with a simultaneous decrease of the blood flow in the renal artery — a type of reaction usually encountered in animals with experimental hypertension (see below).

In contrast to the reflex influences from the carotid sinuses, the "conjugated" interoreceptive influences from the internal organs as per V. N. Chernigovskii (with baroreceptors of the stomach, small intestine and lungs), employed in our experiments, quite frequently were accompanied by active reactions of the renal vessels.

In the pressor reaction from the baroreceptors of the small intestine, together with the peripheral vascular constriction, the opposite reaction of the renal vessels, namely their dilatation, could be observed. Fig. 1,b shows that an increased arterial pressure is accompanied in this case by the slowing down of the peripheral circulation attested by the reduced blood flow rate in the femoral artery and an increased renal circulation as the result of active dilatation of the renal vessels, judging by the reduced outflow of blood in the renal vein. Apparently, the generally observed slight shift of the arterial pressure level at a given reflex (5-15 mm of merc. col.) is the result of contrasting regional vascular reactions. Of 17 experiments in this series, the described reactions of the vessels of the kidney and extremities took place in 16 experiments. In one a constriction of renal vessels was detected and an unaltered blood flow in the femoral vessels — a reaction often encountered in hypertensive animals.

The pressor reflex from gastric mechanoreceptors proceeds with the reduction of peripheral circulation, whereas renal circulation may remain unchanged (Fig. 1,b), or increase passively or actively (dilatation of renal vessels). It should be pointed out that in correspondence with the data of our previous work [4], in the present work, in 6 tests out of 18 we also detected a constriction of peripheral vessels together with the constriction of renal vessels.

For the elicitation of the characteristics of the course of depressor reflexes we investigated the depressor reflex from the respiratory pulmonary passages. Inflation of the respiratory pathways in 11 out of 18 experiments on normal animals was accompanied by the dilatation of the peripheral vessels (in the extremity). In the kidneys, circulatory changes of a predominantly passive nature were observed, and in a number of tests even a dilatation of the renal vessels could be noted. Fig. 1,d shows the dilatation of peripheral and renal vessels following the depressor reflex from the lungs.

The observed regional vascular reactions in experimental hypertension are of a different nature. In animals with experimental hypertension the pressor reactions are accompanied by a frequent reaction of constriction of renal vessels. The peripheral vascular reactions become less pronounced; in a number of cases they cannot be detected at all, and sometimes they even become distorted. Fig. 2,a,d shows the results of observations of hypertensive animals.

As seen in Fig. 2, a,b,c, the pressor reactions from the sinocarotid zones, stomach, and small intestine are accompanied by a slowing down of renal circulation as a result of the constriction of renal vessels. An appreciable reduction of peripheral circulation is observed only upon reflex from the stomach (Fig. 2,c). Of 14 experiments, carried out on hypertensive animals in the study of reflex influences from the sinocarotid zones, the above-described changes of the regional vascular reactions had been observed in 10 experiments; of the 17 tests on reflex influences from the small intestine — in 11; of 15 tests on reflex influences from the stomach — in 10 cases.

A change in the nature of vascular reactions of the kidneys and extremities under conditions of hypertension has been also observed in the depressor reflex from the lungs.

In this case there is a tendency toward more frequent manifestations of active reactions of the renal vessels; however the direction of the reaction is maintained as in healthy animals, i.e., vascular dilatation. In the peripheral vessels a reduction of the blood flow predominates in the arteries and veins (in 16 tests out of 19). Fig. 2,d shows a photorecording of blood flow changes in the renal and femoral vessels under the pulmonary depressor reflex in hypertensive animals.

It should be pointed out that in animals with experimental hypertension a certain reduction of the arterial pressure level can be observed; However, the changes in vascular regional reactions remained characteristic of hypertension.

Thus, experimental hypertension is accompanied by the appearance of a more frequent combination of peripheral vascular reactions with the active reaction of renal vessels, which under pressor reflexes proceeds in the form of spasms, and in depressor reflexes in the form of dilatation of renal vessels. The reactions of peripheral vessels become less pronounced; they are not detected in a number of instances and at times even become distorted.

The obtained data on the peripheral vascular reactions under conditions of experimental hypertension conform to the data relating to clinical-physiological investigations of the peripheral vascular reactivity in hypertensive disease during which conditioned and nonconditioned reflexes were studied [2,6-10, 14, 15].

The character of the regional vascular reaction depends on the extremely complex interrelations of the functional state of the central apparatus of regulation of circulation and the local factors [12].

The detected peculiarities of vascular reactions in the investigated interoceptive reflexes in experimental hypertension apparently depend mainly on the altered functional state of the vasomotor centers.

LITERATURE CITED

1. A. M. Blinova, G. N. Aronova and K. E. Serebryannik, In the book: Neural Regulation of Circulation and Respiration [in Russian], (Moscow, 1952, p. 211.
2. O. L. Bobrova, Med., (1951), No. 1. p. 37.
3. A. I. Vyshatina, Fiziol. Zhurnal, 5, (1959), No. 1. p. 69.
4. A. I. Vyshatina, Byull. Eksper. Biol. i Med., (1960), No. 5. p. 36
5. N. N. Gorev, Essays on the Study of Hypertension [in Russian], (Kiev, 1959).
6. M. I. Gurevich and T. I. Orlova, Quoted by N. N. Gorev, Arkhiv Patol., (1953), Issue 3. p. 3.
7. I. M. Zaalishvili, Transact. of the 2nd Sci. Session on the Problem of Hypertensive Disease [in Russian], (Tbilisi, 1953). p. 169.
8. Yu. M. Ivanov, Terap. Arkhiv (1957). Issue 4. p. 76.
9. S. D. Kaminskii and V. I. Savchuk, Byull. Eksp. Biol. i Med., (1950), Issue 4, No. 10. p. 221.
10. V. A. Kononyachenko, Theses of Reports of the Conference on the Problem of Corticovisceral Physiol. and Pathol., [in Russian], (Leningrad, 1953), p. 93
11. G. S. Lagutina, Byull. Eksper. Biol. i Med., (1959), No. 1, p. 3.
12. M. E. Marshak, Vestnik, AMN SSSR, (1959), No. 9, p. 36.
13. M. E. Marshak, L. I. Ardashnikova, G. N. Aronova, et al., in the book: Regulation of Respiration, Circulation, and Metabolism [in Russian], (Moscow, 1948), p. 65.
14. P. P. Ozolin'sh, Theses of Reports of the Conference on the Problem of Impairment of Circulatory Regulation in the Pathology of the Nervous System [in Russian], (Moscow, 1960), p. 51.
15. G. M. Prikhod'ko, in the book: Problems of the Clinic and Therapy of Diseases of the Cardiovascular System [in Russian], (Kar'kov, 1958), p. 86.
16. V. M. Khayutin, Byull. Eksper. Biol. i Med., (1958), No. 10, p. 18.
17. V. N. Chernigovskii, Zhurn. Vysshey Nervnoi Deyatel'nosti, 6, (1956), Issue 1, p. 53.
18. H. Hartmann, S. L. Orskov and H. Rein, Pflug. Arch. ges. Physiol., 238, (1936), p. 239.