MORPHOLOGICAL EVIDENCE OF HYPERFUNCTION OF THE CELIAC GANGLION IN SPONTANEOUSLY HYPERTENSIVE RATS

L. N. Stebakova, Yu. L. Perov, and Yu. V. Postnov

UDC 616.12-008.331.1-07:616.834-008.61-092.9

KEY WORDS: arterial hypertension; celiac ganglion; SIF cells; kidney.

Several facts are evidence that the sympathetic nervous system participates in the pathogenesis of spontaneous hypertension in rats and that its role is important. These include the impossibility of producing this hypertension after immunosympathectomy, irrespective of whether New Zealand or SHR rats are used [4, 10], increased functional activity of components of the sympathetic trunk [9], etc. However, it must be noted that data on hyperactivity of the sympathetic trunk have been obtained mainly by the study of the superior cervical ganglion. The celiac ganglion (CG) remains virtually unstudied in this respect although it is interesting from several points of view. First, since it occupies a central place in the celiac plexus, it innervates abdominal organs with numerous resistive vessels and thus participates in regulation of the circulating blood volume. Second, electrical activity of the splanchnic nerves is higher in SHR than in control rats [8]. Third, as one of the main sources of innervation of the kidney [6], CG must probably be concerned in the formation of special conditions of kidney function ("resetting"), without which prolongation of arterial hypertension and its conversion into the chronic form are impossible [3, 5, 7]. The role of the renal nerves in the development of "resetting" is only beginning to be studied. The few investigations conducted in this field have been devoted mainly to the physiological effects of denervation, i.e., to intervention directly on the renal nerves. The principal extrarenal sources of innervation, however, have not so far been investigated. Accordingly, in the present study, methods of light-optical and luminescence-microscopic morphometry were used to investigate CG in spontaneously hypertensive rats (SHR).

EXPERIMENTAL METHOD

Altogether 14 female SHR aged 8 weeks and weighing 144 ± 5 g were used. The controls were 14 normotensive NKWR (Normotensive Kyoto Wistar Rats) of the same sex and age. The mean systolic arterial pressure measured in the caudal artery by a plethysmographic method without anesthesia a block of tissue containing CG was quickly isolated from seven experimental and seven control rats, taking bearings from the point where the celiac trunk arises from the anterior surface of the aorta. The tissue was quickly frozen in a cryostat and serial sections were cut to a thickness of 25 μ and treated with glyoxylic acid by the method in [11] or demonstration of chromaffin or SIF (small intensely fluorescent) cells containing catecholamines. The volume of CG and the relative volume occupied in it by concentrations of SIF cells were determined in every 10th serial section by a volumetric method, using an ocular morphometric grid (number of test points 604), followed by approximation of CG to an ellipsoid of rotation. Selective verification of this parameter was carried out by the method of double planimetry [2], with additional staining of the section with hematoxylin and eosin. Material from another seven experimental and seven control animals was fixed in 10% neutral formalin and embedded in paraffin wax; serial sections 5 μ thick were stained with Ehrlich's hematoxylin. The diameter of the neurons and their nuclei was measured with an ocular micrometer. The significance of differences was determined by the Fisher–Student method.

EXPERIMENTAL RESULTS

Hypertrophy of the neurons and their nuclei, of the whole ganglion, and in particular, of the SIF cell population was observed in spontaneous hypertension (Table 1).

Fourth Main Board, Ministry of Health of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR A. I. Strukov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 99, No. 2, pp. 196-198, February, 1985. Original article submitted March 8, 1984.

0007-4888/85/9902-0231$09.50

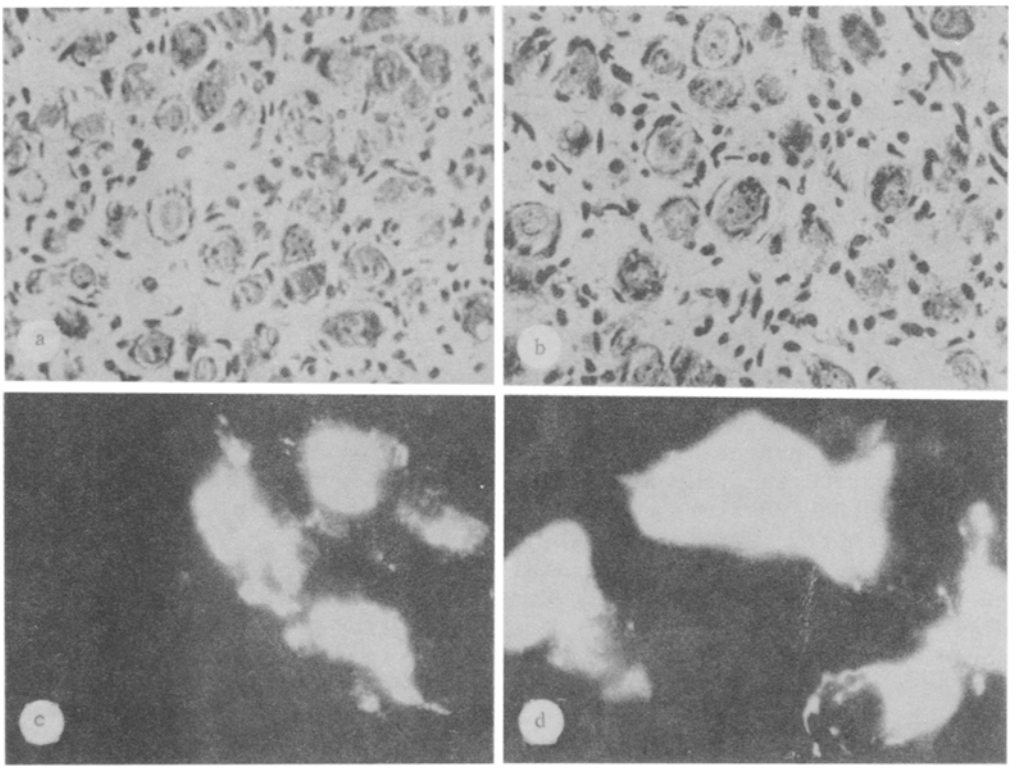

Fig. 1. CG of spontaneously hypertensive rats: I) general appearance: a) control, b) experiment (stained with Ehrlich's hematoxylin and eosin 320 ×); II) fluorescence of concentrations of SIF cells; c) control, d) experiment (method with glyoxylic acid, 320 ×).

TABLE 1. Some Morphometric Parameters of CG of Spontaneously Hypertensive Rats (M ± m)

Experimental conditions	Diameter of neurons, μ	Diameter of nuclei of neurons, μ	Volume of ganglion, mm³	Volume in ganglion occupied by SIF cells, %
Control	19,0±0,3 (7)	9,357±0,25 (5)	0,750±0,118 (7)	0,39±0,07 (7)
Hypertension	20,7±0,3 (7)	10,692±0,32 (5)	1,264±0,082 (7)	0,63±0,09 (7)

Legend. Number of animals given in parentheses. In all cases $P < 0.01$.

Hypertrophy of the neurons and their nuclei and of CG as a whole is evidence of the chronic working overloading (hyperfunction) of this formation. Because of the complexity of the connections of CG and the celiac plexus as a whole, and also because they innervate several organs, intensification of function of CG cannot be regarded as confined to the kidney. At the same time, the kidneys are the largest parenchymatous paired organ among those innervated by the celiac plexus, and it is natural to suppose that changes in them will be reflected more than changes in other organs in the morphology of CG. In other words, hypertrophy of CG and its neurons largely reflects changes in the kidney in the period of formation of hypertensive "switching". Of the four morphometric parameters of CG studied, the greatest increase of all was found in the volume of concentrations of SIF cells, mainly due to their hyerplasia (Fig. 1). The intensity of fluorescence and their high density of distribution prevented any accurate counting of their number, but in cases when the boundaries of the individual cells were distinguishable, there was no doubt about their hyperplasia. In addition, the degree of hypertrophy of concentrations of SIF cells and the increase in frequency of their discovery in serial sections were such that they could not be explained purely

by hypertrophy of the cell bodies without any increase in their number. We know that certain other neuroendocrine cells, for example, those of the APUD system, undergo marked hyperplasia in a number of pathological states.

SIF cells are nowadays regarded as a heterogeneous population possessing endocrine (paracrine) properties and properties of typical nerve cells simultaneously. On account of epinephrine, dopamine and, perhaps, other neurotransmitters they participate actively in the interneuronal transmission of impulses in the territory of the ganglia: they weaken or strengthen it considerably and thereby play the role of interneurons or paraneurons. Irrespective of whether SIF cells secrete their own mediators into capillaries surrounding neighboring neurons (endocrine function), or directly into these cells (paracrine function), or whether they are incorporated into a reflex arc through the rich synaptic connections (interneuron function in the narrow meaning), their hypertrophy in CG reflects essential intensification of intraganglionic nervous processes in hypertension. SIF cells are more sensitive than neurons, and are a component of CG in other pathological states [1]. Thus despite the fact that the volume even of hypertrophied concentrations of SIF cells remains comparatively small, the functional importance of this growth is great. We know that the intensity of function of the nervous system depends not so much on the number and size of the neurons as on the richness and complexity of the connections between them. SIF cells, which are short-chain (local) neurons, maintain the width and intensity of short-distance connections on the terriotry of CG, and it is natural, therefore, that their functional role should be much greater than their relative volume in the organ suggests.

The morphology of CG is thus evidence of its chronic hyperfunction in spontaneously hypertensive rats. Evidently not only hemodynamic and humoral factors take part in the "resetting" of the kidney during the development of hypertrension, but also the extrarenal section of the renal innervation.

LITERATURE CITED

1. S. A. Kakabadze, "Morphological and functional characteristics of the celiac ganglia from the age aspect and in hypokinesia," Author's Abstract of Candidate's Dissertation, Moscow (1983).
2. V. S. Kesarev, Byull. Éksp. Biol. Med., No. 8, 120 (1964).
3. Yu. V. Postnov, Kardiologiya, No. 12, 30 (1979).
4. Yu. V. Postnov, S. N. Orlov, and N. I. Pokudin, Pflug. Arch. Ges. Physiol., 390, 256 (1981).
5. Yu. V. Postnov, K. A. Fofanova, and G. A. Fedina, Kardiologiya, No. 11, 15 (1970).
6. V. N. Shvalev, Innervation of the Kidneys [in Russian], Moscow–Leningrad (1975).
7. A. C. Guyton, T. I. Coleman, and H. J. Granger, Annu. Rev. Physiol., 34, 13 (1972).
8. J. Iriuchijima, Jpn. Circulat. J., 37, 1251 (1973).
9. M. Matsumoto, Jpn. Circulat. J., 33, 411 (1969).
10. F. H. Smirk, Cir. Res., 26-27, Suppl. 2, 55 (1970).
11. J. C. Torra and W. Surgeon, Histochemie, 49, 81 (1976).