6. M. I. Razumov, Vopr. Pitaniya, No. 4, 18 (1952).
7. D. S. Sarkisov, Regneration and its Clinical Importance [in Russian], Moscow (1970), pp. 99-110.
8. A. M. Ugolev, Contact Digestion [in Russian], Leningrad (1972), pp. 116-122.
9. B. Creamer, J. Roy. Coll. Phys. London, 5, 323 (1971).
10. H. David, Arch. Path. Anat., 342, 19 (1967).

STATE OF THE NERVOUS APPARATUS OF THE MENINGES AFTER BILATERAL LIGATION OF THE COMMON CAROTID ARTERIES

G. A. Konstantinovskii

UDC 616.833-031:611.819/-02:616.133-007.272-092.9

Bilateral ligation of the common carotid arteries was followed by marked changes in the nervous apparatus of the meninges, leading in some places to the reorganization of neurovasal relations.

KEY WORDS: meninges; carotid arteries; peripheral nervous system.

The nature of the collateral circulation of the brain and its meninges after extracranial occlusion of the main vessels of the head is at present a matter for special attention of both clinicians and theoreticians [2,7, 15,16]. However, no mention could be found in the accessible literature of the state of the nervous apparatus of the blood vessels of the brain and its meninges in disturbances of this type or, in particular, in extracranial lesions of the carotid arteries, the frequent cause of softening of the cerebral hemispheres [7,15]. Nevertheless, such information is particularly relevant to the deeper analysis of these processes for the responses of blood vessels are largely dependent on the state of their innervation [3-5,11].

The object of this investigation was to study the state of the nervous apparatus of the meninges after bilateral ligation of the common carotid arteries.

EXPERIMENTAL METHOD

The meninges from the brains of 32 healthy, sexually mature dogs (24 experimental and eight control animals) were used as the test object. The experiments were carried out on dogs because the principle of construction of the vascular system of the brain and the innervation of the meninges in these animals are similar in many respects to those observed in man [6,8,14].

Under sterile conditions the middle part of the common carotid arteries of the experimental dogs was exposed and completely ligated with a Kapron thread (each vessel at two places). The animals were killed at different times after the operation: 1, 3, 7, 30, 90, and 120 days (four dogs in each group).

The meninges were investigated in total preparations. Nerve cells were detected by impregnation with silver nitrate by the Bielschowsky–Gros, Rasskazova, and Campos methods, by means of which the vascular network could be demonstrated at the same time. After impregnation with silver, the preparations were gilded and stained with hematoxylin–eosin, azure II–eosin, or picrofuchsin so as to detect the other tissue elements. The myelin sheath of the nerve fibers was stained with hematoxylin lake by Spielmeyer's method or with osmic acid by Schultze's method.

Department of Histology and Embryology, Kiev Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR A. P. Romodanov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 9, pp. 1135-1138, September, 1976. Original article submitted October 28, 1975.

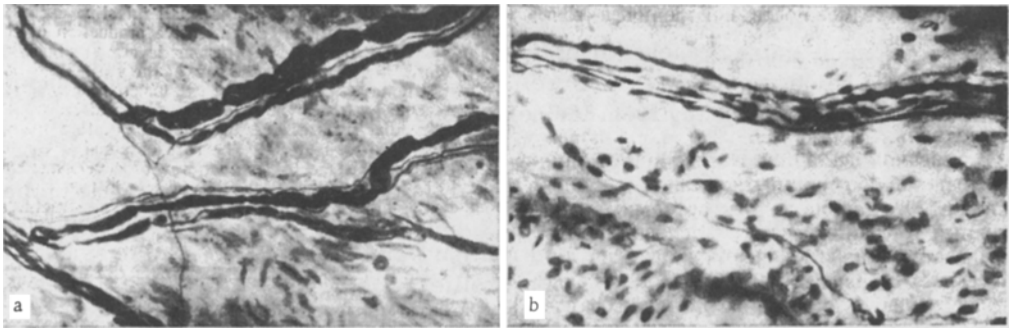

Fig. 1. Swelling of individual nerve fibers in dura (a) and pia (b) mater 3 days after ligation of common carotid arteries. Impregnation by Rasskazova's method, gilding, staining with hematoxyline-eosin; 400 ×.

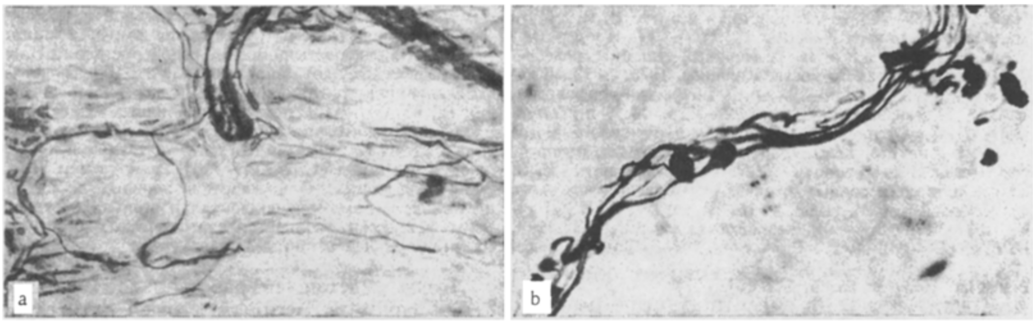

Fig. 2. Dura mater: a) proliferation of nerve fibers near obliterated vessel 30 days after operation; b) microneuromas along course of nerve fibers 90 days after operation. Impregnation by Bielschowsky–Gros method, gilding, hemalum, staining with azure II-eosin; 420 ×.

EXPERIMENTAL RESULTS

By the 3rd-4th day after the operation no marked clinical disturbances were observed in the dogs, in agreement with the findings of other workers [1,4,10,13].

After simultaneous ligation of both carotid arteries many and varied morphological changes developed rapidly in the nerve cells of the meninges (in the stroma and the blood vessels passing through it). In the first week after the operation they were manifested mainly as processes interpreted in the literature as "irritation phenomena": an irregular impregnation of different parts of some axons, the appearance of varicosities and pools along their course, the presence of small pale vacuoles in the axons and in the myelin sheaths, and thickening of the terminals and of the boutons terminaux (Fig. 1). Individual fibrils in a state of degeneration and disintegration also were seen. These changes in the peripheral nervous system were initially diffuse in character and were not confined to areas receiving blood from the carotid vessels. For instance, they were more severe in the pia mater of the brain stem, which receives blood from the vertebral arteries; the reason for this was evidently deprivation of this part of the brain of blood because of its switching through the powerful collectors of the circle of Willis from the vertebral-basilar into the carotid systems. These results agree with clinical observations indicating that thrombosis of the carotid arteries is frequently accompanied by symptoms arising from the brain stem; a phenomenon of "plundering" arises as a result of the switching of some blood from neighboring vessels into a blocked cerebral vessel [16]. The possibility of trauma to the sympathetic plexus during ligation of the carotid arteries must also be taken into account, for individual fibrils of that plexus participate in the innervation of the superficial vessels of the brain [12,18].

Later (30 days after the operation) the reactive changes in the nervous apparatus of the meninges, in the form of phenomena of irritation and destruction, were seen less frequently. The exception was the dura of the vault of the skull where in some places the lumen of some arteries was partly or completely obliterated. Many nerve fibers in the walls of these vessels were in a state of destruction, including axons penetrating into them from nerve bundles accompanying these arteries. Meanwhile, these bundles in the areas adjacent to the meninges frequently gave off many more branches than in the control animals. In total preparations growth of individual terminals could be observed toward the well preserved unchanged blood vessels and newly formed collaterals, sometimes located a long way from the nerve bundle (Fig. 2a).

In the vessels of the pia mater the phenomena of obliteration were not so severe. Only on the dorsolateral surface of the frontal, parietal, and temporal lobes and cerebellum were some of the pial arteries rather narrower than normally. Their adventitia was frequently less saturated with nervous structures. In individual (mainly small) arteries single axons in a state of destruction were found. Menwhile, besides dilatation of the posterior communicating and basilar arteries [10,17], proliferation of nerve fibrils and the appearance of more powerful polyvalent receptors also were observed in the adventitia of these vessels.

Between 90 and 180 days after bilateral ligation of the common carotid arteries when according to data in the literature and our own observations, compensation of the circulation through the development of many direct anastomoses in the neck is complete [4,13], the angioarchitectonics and structure of the peripheral nervous system in some parts of the meninges still remained abnormal. This was particularly marked in the inner layer of the dura – in the region of the vault of the skull. Besides territories with a less dense vascular network than normally, other small areas were also seen here in which dilated arterial and arteriovenous anastomoses were more numerous than in the control material. Areas with a poorly developed vascular network frequently contained fewer nerve fibers and more primitive terminal apparatuses than the richly vascularized areas. Many nerve endings in them were visibly thickened and were more intensively impregnated with silver. Along the course of some axons microneuromas could be seen (Fig. 2b). Individual nerve fibrils were in a state of fragmentation. Changes of this type were less frequently seen in areas with a rich vascular network.

So far as the pia mater is concerned, appreciable morphological reactions were observed here only in the region of the brain stem, where the posterior communicating and basilar arteries were dilated, as before, and their adventitia in many places contained more powerfully developed external and internal nervous plexuses and had a higher concentration of nerve endings, including polyvalent, than in the control animals.

These investigations thus showed that adaptation of the vascular system to the new conditions after stoppage of the blood flow through the common carotid arteries is accompanied by marked changes in the nervous apparatus of the meninges, leading in some places to a reorganization of neurovasal relations. Not only in their intensity, but also in their character these changes differed essentially from those described previously after unilateral ligation of the same vessels [9]. The discription given above suggests that the nervous apparatus in some parts of the meninges is highly sensitive not only to disturbances of the circulation of cerebrospinal fluid [8], but also to disturbances of the blood flow along the main vascular trunks.

LITERATURE CITED

1. L. A. Andreev, Arkh. Biol. Nauk, 45, No. 2, 203 (1937).
2. I. V. Ganushkina, The Collateral Circulation in the Brain [in Russian], Moscow (1973).
3. N. A. Dzhavakhishvili and E. P. Mel'man, Arkh. Anat., No. 2, 21 (1974).
4. B. A. Dolgo-Saburov, Outlines of the Functional Anatomy of Blood Vessels [in Russian], Leningrad (1961).
5. N. I. Zazybin, in: Morphology of Reactive Changes in the Peripheral Nervous System [in Russian], Kiev (1966), pp. 5-15.
6. B. N. Klosovskii, The Circulation of Blood in the Brain [in Russian], Moscow (1951).
7. A. N. Koltover et al., Pathological Anatomy of Disturbances of the Cerebral Circulation [in Russian], Moscow (1975).
8. G. A. Konstantinovskii, "Age changes and reactive properties of the peripheral nervous system of the meninges," Doctoral Dissertation, Kiev (1968).
9. G. A. Konstantinovskii and V. P. Yatsenko, in: Morphogenesis and Regeneration [in Russian], No. 5, Kiev (1973), pp. 20-25.
10. E. N. Kosmarskaya, Zh. Nevropatol. Psikhiat., No. 9, 702 (1953).
11. V. V. Kupriyanov, Pathways of the Microcirculation [in Russian], Kishinev (1969).
12. V. V. Kupriyanov and V. T. Zhitsa, The Nervous Apparatus of the Blood Vessels of the Brain [in Russian], Kishinev (1975).
13. A. P. Lyubomudrov, in: Problems in Morphology [in Russian], No. 3, L'vov (1968), pp. 92-97.
14. D. A. Sigalevich, "Nerves of the dura mater of man and certain mammals," Author's Abstract of Candidate's Dissertation, Simferopol' (1952).

15. E. V. Shmidt, Stenosis and Thrombosis of the Carotid Arteries and Disturbances of the Cerebral Circulation [in Russian], Moscow (1963).
16. E. V. Shmidt, D. K. Lunev, et al., Zh. Nevropatol. Psikhiat., No. 6, 801 (1974).
17. R. D. Lowe, Circulat. Res., 10, 73 (1962).
18. R. G. Williams, J. Comp. Neurol., 66, 77 (1937).

FIXATION OF HUMAN SERUM ANTIBRAIN ANTIBODIES IN DIFFERENT PARTS OF THE RABBIT BRAIN

I. V. Gannushkina

UDC 616.831-008.9-097.5-078.73:576.8.073.4

The indirect immunofluorescence method of Coons was used to study the character of fixation of antibrain antibodies (ABA), contained in the sera of patients with essential hypertension, amyotrophic lateral sclerosis, multiple sclerosis, hepatocerebral degeneration, and myoclonia epileptica on rabbit brain sections. ABA complementary to different structures of nerve tissue were always formed in these diseases. The antigenic properties of the individual brain tissue components of the patients were not altered to the extent of differing completely from the entigenic properties of the same formations in normal animals. Meanwhile different components of nerve and glial cells, the myelin sheaths of various conducting systems and, to a lesser degree, cells of the ependyma and walls of blood vessels located in different parts of the brain possessed not only common, but also different antigenic propeties.

KEY WORDS: antibrain antibodies; essential hypertension; amyotrophic lateral sclerosis; multiple sclerosis; hepatocerebral degeneration; myoclonia epileptica.

More than 10 water-soluble and water-insoluble brain-specific antigens have now been found and identified in the tissues of the central and peripheral nervous systems: proteins S-100 and 14-3-2, BE-antigen, α_2-glycoprotein, α-antigen, and so on [3,6,9,12,13,17-19]. Not only antigens of gray and white matter, but also antigens of various parts of normal and pathologically changed brain tissue have been determined by various methods [1,5,7,14-16]. Meanwhile the location of the antigenic determinants in nerve and glial cells, in myelin sheaths, and in the walls of blood vessels situated in different anatomical formations of the brain has still received little study [4,8,11,20].

The object of this investigation was to determine the fixation sites of antibrain antibodies (ABA) on the above-mentioned tissue structures of the brain in order to ascertain their antigenic similarity and differences.

EXPERIMENTAL METHOD

Coons' immunofluorescence method in its indirect modification was used [10]. Whole blood sera from 10 patients with essential hypertension, 16 with amyotrophic lateral sclerosis (ALS), 12 with multiple sclerosis (MS), seven patients with hepatocerebral degeneration (HCD), and four patients with myoclonia epileptica were used as the AMA. Blood sera from 50 donors, the results of testing which have already been reported [4], were used as the control.

Frontal sections of unfixed rabbit brain taken 1-2 min after decapitation were used as the nerve tissue antigen. After rapid cooling of the brain on dry ice, sections were cut in a cryostat at −20°C. Sections for investigation were taken at the level of maximal development of cortical area 4, at the level of the caudal part

---

Research Institute of Neurology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR E. V. Shmidt). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 9, pp. 1138-1141, September, 1976. Original article submitted January 6, 1976.