PRENATAL MORPHOGENESIS OF THE CAROTID SINUS BAROCEPTORS IN MAN

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The formation of baroceptors in the carotid sinus reflexogenic zone during human prenatal development (starting from the 4th month of pregnancy until the neonatal period) was studied. Nervous structures were revealed by the Campos impregnation technique. Most sensory nerve endings were found in the deep layers of the adventitia of the carotid sinus. Starting from the 6th-7th month, two different types of afferent nerve endings were observed in the carotid sinus zone: baroceptors of types 1 and 2. The former are endings of myelinated nerve fibers of small caliber (2-3 μ); the latter are endings of thicker myelinated fibers (4-6 μ). Many of the morphological structural features of the conducting, preterminal, and terminal portions of the baroceptors characteristic of the sensory nerve endings in the adult were visible in the wall of the carotid sinus throughout the period of intrauterine development of the human fetus investigated.

A study of the innervation of the carotid sinus reflexogenic zone in clinically healthy persons and animals [1, 5-7] has shown that the afferent nerve structures of this vascular zone possess morphological features that are usually regarded as evidence of the reactive or pathological state of the nerve structures. These include, in particular, hyperplasia of the axoplasm along the course of the conducting and preterminal portions, irregularity of the caliber of the nerve fibers, the eroded contours of the axons, hyperargentophilia, etc. Disagreements in the literature regarding this peculiarity of the carotid sinus baroceptors make further studies of their structure imperative. In this connection research from the aspect of age morphology is particularly important, for knowledge of the morphogenesis of the carotid sinus baroceptors would help to explain the features distinguishing their structural organization in the adult state. Meanwhile the literature on this question is extremely scanty and it does not provide a full picture of the consecutive stages of formation of the carotid sinus baroceptors.

The prenatal period of morphogenesis of the carotid sinus baroceptors has received the least study. Only a few papers can be cited and they give only fragmentary information about the intrauterine development of the sensory nervous apparatus in the wall of the carotid sinus in man and 7 mammals [4, 9, 15]. The present investigation was carried out to fill this gap.

EXPERIMENTAL METHOD

Human fetuses were investigated starting from the 4th month of pregnancy and continuing until the neonatal period. Altogether 44 carotid sinuses were examined from 22 fetuses of both sexes: 12 aged 4-5 months, 10 aged 6-7 months, 10 aged 8-9 months, 12 aged 10 months or newly born.

In most cases material was taken not later than 7-8 h after death of the fetus, fixed in 12% neutral formalin solution for 2-3 weeks, and then treated by the Campos inpregnation method. Sections in parallel planes or tangential sections through the wall of the carotid sinus were examined under the microscope.

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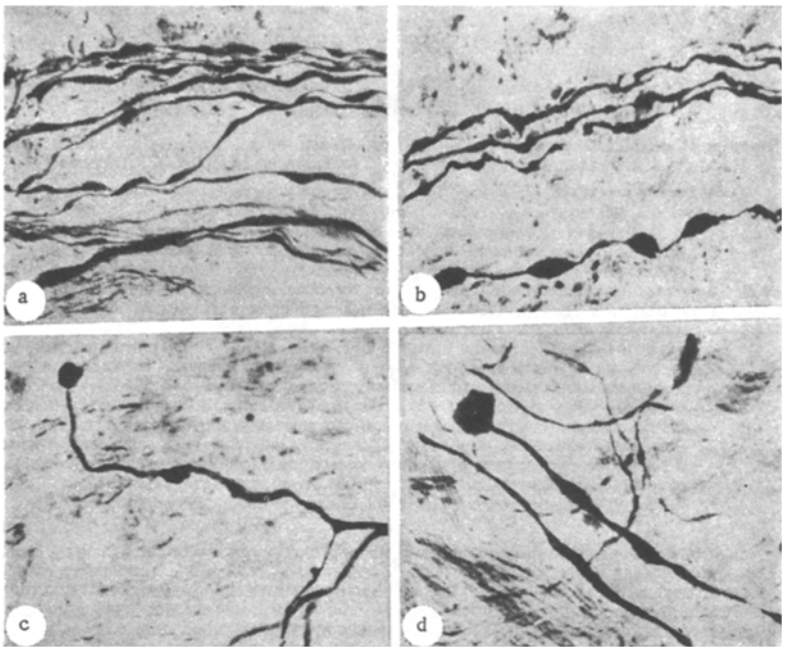

Fig. 1. Nerve fibers from the wall of the carotid sinus of human fetuses: a) 5 months, b) 8 months, c) 6 months, d) 7 months. Impregnation by Campos method, 500×.

EXPERIMENTAL RESULTS

The observations showed that a well-marked innervation system is visible in the wall of the carotid sinus as early as 4-5 months. It consists of a system of branches of numerous bundles of nerve fibers lying in the substance of the adventitia of the carotid sinus. The nerve bundles consist mainly of myelinated fibers of small (2-3 μ) and average (4-6 μ) caliber. Nerve fibers of larger caliber – about 7.8 μ – were much less numerous. Besides myelinated fibers, the bundles also contained unmyelinated nerve fibers. Some of them were collaterals of myelinated fibers whereas others were an independent category of unmyelinated autonomic C-fibers. This last group is responsible for the effector innervation of smooth-muscle cells and of the vasa vasorum, which are abundantly developed in the adventitia of the carotid sinus.

A characteristic feature of the myelinated nerve fibers (both in bundles and scattered) was the numerous spindle-shaped enlargements along their course caused by alternate wide and narrow regions of the axoplasm. At the same time, along the course of the nerve fibers there were larger spherical or oval pools of axoplasm, impregnated strongly with silver salts (Fig. 1a, b). The same structures frequently crowned the conducting or preterminal portions of the nerve fibers rather like terminal bulbs of growth (Fig. 1c, d).

Starting from 6-7 months, individual nerve fibers in the wall of the carotid sinus acquired the distinctive configuration known as the phenomenon of erosion (or beading) of the contours of the axons (Figs. 1b and 2b, c, d). This phenomenon was found first on myelinated fibers of larger caliber. As analysis of the specimens shows, this phenomenon was due entirely to the structural features of the axoplasmic components of the nerve fibers. Toward the end of the prenatal period the number of nerve fibers showing the phenomenon of erosion of axon contours increased considerably, indicating the regular appearance of this phenomenon as a structural feature of the nerve fibers of the carotid sinus in the stage of their prenatal morphogenesis. These observations agree fully with the view that afferent nerve fibers of the carotid sinus and other vascular reflexogenic zones vary in character under normal physiological conditions, and one form of this variation is the phenomenon mentioned above [1,5-7].

Comparative analysis of preparations belonging to different age periods of prenatal ontogeny shows the gradual development of an increasingly complex system of preterminal and terminal branches of myelinated nerve fibers takes place in the wall of the carotid sinus. At the stage of 4-5 months, for instance, a few arborizations of nerve fibers, branching dichotomously, can be seen in the carotid sinus zone; these can be regarded only conditionally as terminal acceptor structures (they are essentially preterminal portions that are still growing). By 6-7 months these same sensory nerve structures have reached the degree

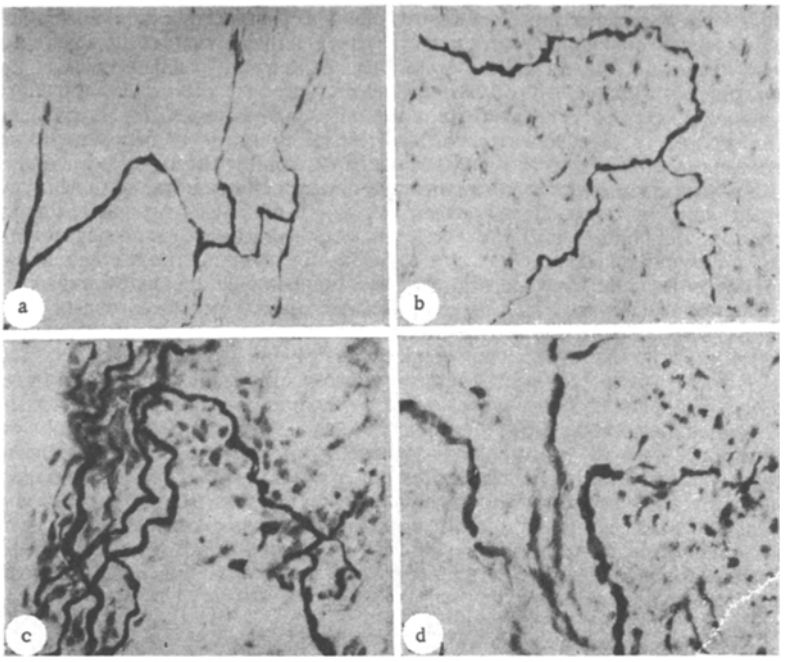

Fig. 2. Preterminal and terminal portions of baroceptors of types 1 (a, b) and 2 (c, d): a) 4 months, b) 9 months, c) 8 months, d) 10 months. Impregnation by Campos method, 400×.

of development and differentiation at which they can be seen to belong to certain types of receptor structures. In most of them these are terminal arborizations, resembling trees or shrubs depending on their extent, but not yet containing any special neurofibrillary or neuroplasmic structure on their ends (Fig. 2a, b). In de Castro's classification [9] these sensory nerve endings correspond to carotid sinus baroceptors of type 1. Besides these, starting from 7 months another type of receptor endings can be distinguished in the wall of the carotid sinus. They have a compact type of terminal branching, ending in terminal structures consisting of bouton-like expansions, loops, and reticular plaques (Fig. 2c, d). According to de Castro's classification, this form of sensory nerve endings belongs to the group of carotid sinus baroceptors of type 2. On the whole, however, the morphological picture of the developing innervation system in the wall of the carotid sinus is characterized by many intermediate forms of nerve endings, some resembling more closely the type 1, others the type 2 baroceptors. This can be explained on the assumption that throughout the period of intrauterine development of the fetus studied, a process of formation of young receptor structures, accompanied by intensive growth of axons and their preterminal and terminal portions, continues in the carotid sinus reflexogenic zone. These observations are perfectly reasonable if it is remembered that the development and formation of the carotid sinus baroceptors (like the baroceptors of the other vascular reflexogenic zone) continue not only for many months after birth, but actually for the first few years of human life [2, 3, 9-14].

Meanwhile the results of this investigation indicate that many important features distinguishing the structural organization of the carotid sinus baroceptors in the adult state appear at a stage of intrauterine development of the fetus characterized by the intensive formation of the innervation system of the carotid sinus reflexogenic zone as a whole. This fact emphasizes the importance of investigation of the age morphology of the carotid sinus baroceptors in order to obtain a correct idea of the limits of morphological variability of these afferent nerve structures under normal and pathological conditions.

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