

# MORPHOLOGY AND PATHOMORPHOLOGY

## THE MORPHOLOGY OF BARORECEPTORS OF THE AORTIC ARCH OF PUPPIES DURING POSTNATAL DEVELOPMENT

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In works published recently dealing with the morphology of the sensory nervous supply from the depressor zone of the aortic arch and openings of the pulmonary and great veins of various animals [19,20,21] it has been shown that the thick and medium myelinated fibers forming compact bushy receptors in these reflexogenous vascular zones normally display a variety of morphological features (in the cat, dog, and monkey). On the axons of these nerve fibers there are swellings of various shapes and sizes, which possess various degrees of argentophilia. Between the swellings the axons are very thin and there are demyelinated zones. The terminal receptors formed by these fibers vary greatly in thickness and in the extent to which they are impregnated with silver; a portion of the termination is highly argentophil and diffusely impregnated; it appears as though there is a break in the structure of the termination. Similar morphological features of the thick myelinated fibers and of the aortic arch receptors in healthy animals has been found by Abraham [24]; these structures have been found by V. P. Kurkovskii [11] at the orifice of the inferior vena cava of cats, and by Nonidev [25] at the openings of the venae cavae of dogs and cats.

It would appear that these observations should leave no doubt that the characteristic features of the structures we have just described are attributes of the baroreceptor fibers and endings of the reflexogenous zones. However, these studies have been criticized. Many authors who have studied the histopathology of the sensory apparatus of the reflexogenous vascular zones in various human diseases [4,5,6,10,12,15,23], and also in various experiments on animals [1,3,8,13,14] have interpreted these baroreceptor structures as pathological phenomena.

Two diametrically opposed interpretations of the morphological attributes of the thick fibers and receptors of the reflexogenous zones have been put forward; it has therefore become essential to study further the morphology of the baroreceptor apparatus in normal animals. We have made this study at various postnatal stages in animals.

A gradual increase in the complexity of the architectonics of the receptors of these zones during development and growth of embryos and fetuses of man and animals has been described [5,7,8,22,25,26]. However, only a few of the investigators have directed their attention to the uneven thickenings along the length of the thick nerve fibers. I. P. Gutner found thickenings of the nerve fibers in the aorta of a seven-month human embryo, and interpreted them as a consequence of the pathology of pregnancy. A. G. Chernyakhovskii and Nonidev thought that the appearance of thickenings along the length of the baroreceptor nerve fibers did not arise by chance; in the opinion of these authors the structures were characteristic of the sensory fibers of the depressor nerve and were of functional significance. It was suggested that these voluminous swellings on the preterminal receptors represented a characteristic receptor apparatus having a low threshold and responding to very small variations of blood pressure in the vessels (aortic arch, orifices of the venae cavae and pulmonary veins). However, according to A. G. Chernyakhovskii and Nonidev such receptors respond only to sudden variations of pressure within the vessel.

From what has been published it is not clear at what stage of development the baroreceptor nervous apparatus acquires the morphological features which have been found to be present in healthy adult animals, or whether the appearance of these morphological features is brought about by functional changes. According to some authors [19,24,25] the baroreceptors in the aortic arch are disposed compactly, forming a more marked reflexogenous zone than occurs in other vessels; therefore in this report we have paid special attention to material displaying baroreceptors in the depressor zone of the aortic arch in puppies.

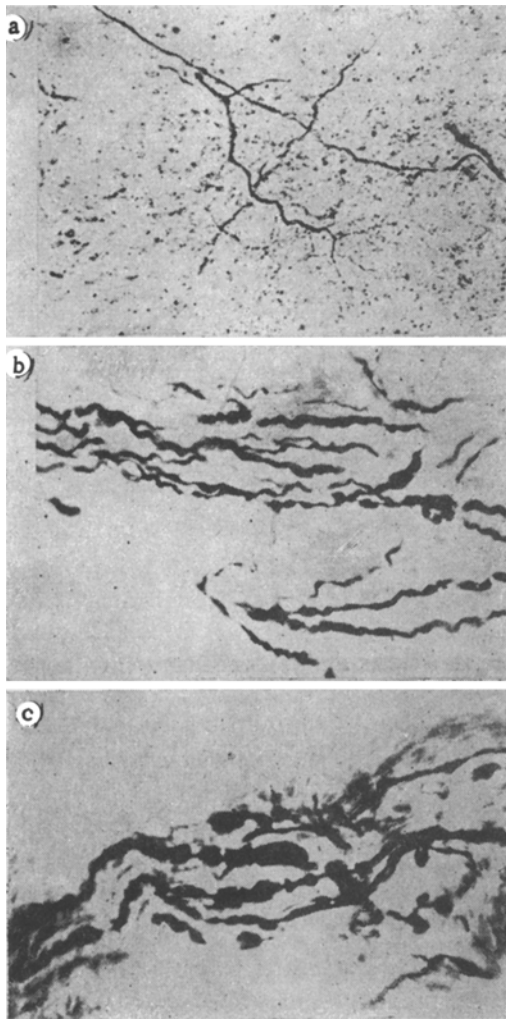


Fig. 1. Structure of the fibers from the reflexogenic zone of the aortic arch in puppies at various ages. a) 10 days; b) 25 days; c) 3 mos. Impregnation with Campos. Magnification  $10 \times 40$ .

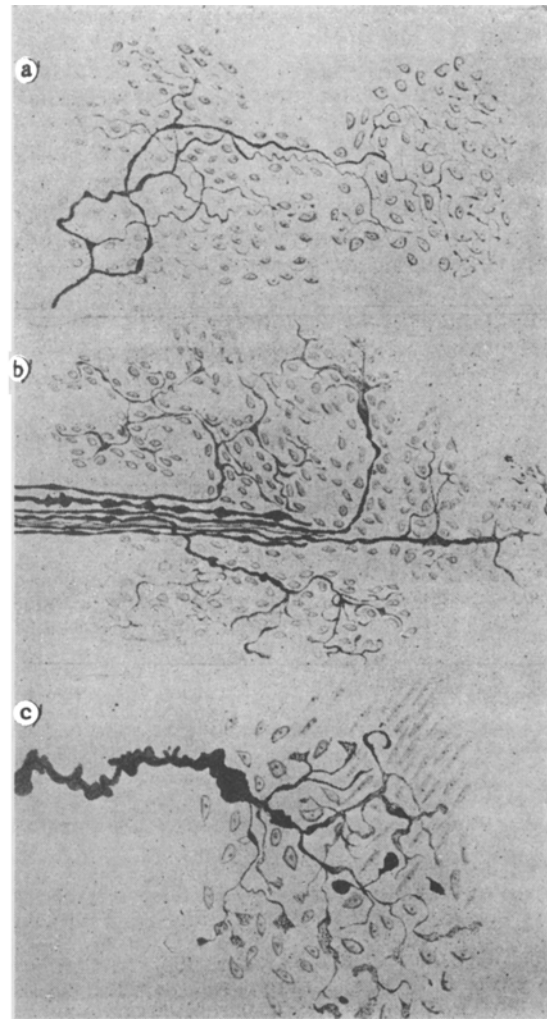


Fig. 2. Receptors of the reflexogenic zone of the aorta of puppies at various ages. a) 10 days; b) 30 days; c) 2 mos. Impregnation with Campos. Magnification  $10 \times 40$ .

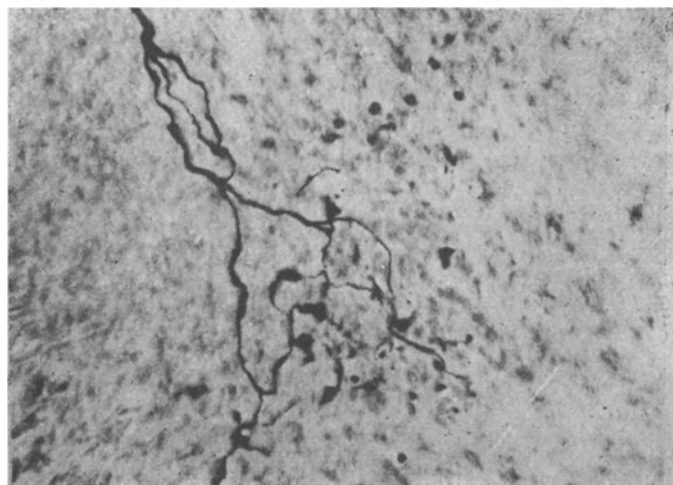


Fig. 3. Receptors of the aorta of a puppy aged 3 mos. Impregnation with Campos. Magnification  $10 \times 40$ .

## EXPERIMENTAL METHOD

The aortic arch of puppies was treated with Campos solution. The puppies were killed in various ways: by guillotining, by an air embolism, by a mixture of chloroform and ether, or by electrocution. It was found that the different methods of killing produced no differences in the structure of the nerve fibers or receptors in the reflexogenous zone of the aortic arch in corresponding age groups. Therefore the means by which the animals is killed produces no noticeable effect on the structure of the nervous apparatus of the aortic arch.

## EXPERIMENTAL RESULTS

In the very first days of life (up to 10 days) all the fibers in the reflexogenous zone of the aorta are smooth and even and have scarcely noticeable fibrillar expansions (Fig. 1, a). Their terminal portions are formed from very fine dichotomously dividing fibers which are in a condition of growth, as shown by the presence at the ends of small growth cones (Fig. 2, a).

In puppies ages 25-30 days, in the fibers of thick and medium caliber which enter the reflexogenous zone of the aorta from the surrounding adventitia in bundles, and in the solitary nerve fibers of the same caliber lying in the areolar connective tissue within the zone, uneven swellings of various degrees of argentophilia are found (Fig. 1, b). There is also an increase in the number of terminal receptors, and their caliber is increased; however, along the terminal branches and at their ends dark reticular fibrillar structures are present (Fig. 2, b). In older puppies, two months after birth, the nerve fibers and the terminal receptors themselves become argentophil. Along the length of the fibers and particularly in the preterminal portions, dilatations in the form of uneven swellings appear (Fig. 2, c). The terminal portions of the receptors become more and more complex. They are more compact, the number of branches increases and the size of the reticular plates along the course of the branches of the receptor there appear evenly staining hyperargentophil regions; the terminal fibrillar expansions become coarser in structure, and some of them are crenated.

Between the second and third postnatal month, on the thick myelinated fibers there appear ever more marked signs of those morphological features which are characteristic of the nerve fibers in this zone of the adult animal. In the preterminal portions uneven swellings of the axis cylinder and sheath appear, and alternate with extremely thin portions of axon; along these nerve fibers there is a markedly uneven argentophilia (Fig. 1, c). Many of the terminal branches of the receptors lose their fibrils, become coarser, and after impregnation with silver they appear evenly black. Frequently isolated terminal structures can be seen which appear to have been torn off and to represent broken-off receptors (Fig. 3).

Thus in puppies at the postnatal stage, as the terminal portion of the baroreceptors is formed morphological features appear which distinguish the baroreceptors of the reflexogenous vascular zones of the adult. We must emphasize that in the same animals and in the same reflexogenous zone many of the fine unmyelinated and myelinated nerve fibers remain unchanged, smooth, and evenly impregnated with silver.

Because we have observed the development of the structure of the baroreceptors of the aortic arch in the postnatal period of completely healthy puppies there is no need to invoke any pathological events or to classify the different morphological phenomena characteristic of the structure of the terminal baroreceptors as compensatory, destructive, or degenerative changes.

We may confidently assert that the baroreceptors of the aortic arch gradually acquire the features characteristic of the adult during the postnatal period. The initial indications of these morphological features can be observed at about the 25-30th day of life, and by the age of two months or more the baroreceptors and their characteristic afferent fibers acquire all the features present in the corresponding structures of the adult. It is interesting to note that many physiological investigations [2,9,16,17,18] have shown that in puppies vagal tone is very weak at the early postnatal period, and the explanation has been that the reason is the absence of vagal tone.

According to the authors mentioned above the inhibitory effect on the heart appears in puppies by the 2½-3rd month. Therefore the maturation of the baroreceptor structure coincides with the appearance of an inhibitory influence on the heart, an effect which, as is known, depends upon the presence of tonic excitation of the vagal centers regulating the heart centers which themselves are under the influence of receptors in the heart and reflexogenous vascular zones. Naturally, on the basis of our observations we cannot assert that the morphological features of the baroreceptor fibers and of the terminations which we have observed indicate functional maturity; nevertheless the fact that the physiological and morphological events coincide is a point of great interest, and allows us to put forward certain proposals.

The thought arises that at the early postnatal stage the growing but not yet formed sensory nervous apparatus of the cardiovascular zones, which include the depressor zone of the aortic arch, is unable to exert the required tonic vagal excitation.

We are inclined to think that the morphological features of the structure of the baroreceptors of the reflexogenous vascular zones described by Abraham, V. P. Kurkovskii, and E. B. Khaisman, and by some other authors represent a normal histophysiological condition.

The use of histochemical and other methods has demonstrated the existence not only of the morphological features here described in the living animal but also that these baroreceptor structures are related to the normal physiological condition [21]. The interpretation of these structures as pathological must be reconsidered, and further work is required to elucidate their functional significance.

#### SUMMARY

Examination of the thick nerve fibers and of the receptors of the reflexogenous zones of the aortic arch of healthy puppies of various ages showed that in the postnatal period the baroreceptors of the aortic arch gradually acquired the characteristic features of normal adult animals. The first sign of these characteristic features appeared by the 25-30th day, but after two months and later the baroreceptors and the corresponding afferent fibers displayed all the features present in the corresponding structures of healthy adult animals.

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