ADRENERGIC TERMINAL STRUCTURES IN THE MAMMALIAN MESENTERY

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Adrenergic terminal structures in the mammalian mesentery were studied by fluorescence microscopy of catecholamines. The basis of the adrenergic innervation of the mesentery was shown to consist of well-developed perivascular plexuses. At many points of these plexuses, single adrenergic fibers were seen to emerge into avascular regions of the mesentery, where through repeated dichotomous division, they were transformed into preterminal and terminal structures. These innervation structures, built in accordance with the principle of spreading or limited arborizations, showed common morphological features with free sensory nerve endings.

KEY WORDS: adrenergic nerve structures; innervation of mesentery.

Terminal (synaptic) structures of the autonomic nervous system have long attracted the attention of neuroanatomists. The establishment of their existence was at the time of their discovery a decisive factor in resolving the long-lasting dispute between supporters of the syncytial and neuronal structure of the peripheral portions of the autonomic nervous system [2-4, 7]. However, problems concerning the morphology of autonomic tissue synapses have not lost their urgency and they continue to receive systematic study. The reason is not only the functional role of the terminal portions of the autonomic nervous system in the mechanism of the effector autonomic innervation, but also the insufficient study which their structure has so far received. For many years investigators have inevitably met with technical difficulties when demonstrating the terminal portions of the autonomic nervous system by classical neurohistological methods (impregnation with silver salts, supravital staining with methylene blue). Radical changes in the study of this problem have occurred only in the last decade with the introduction of the fluorescence-microscopic method of Falk and Hillarp [10], by means of which adrenergic (sympathetic) structures can be selectively revealed. By the wide use of this method, many investigations have been carried out in which a detailed description has been obtained of the structure of adrenergic nervous plexuses and their terminal synaptic structures in various organs and tissues. These include investigations of the adrenergic innervation of the mammalian mesentery [8, 11]. Interest of research workers in this object can be attributed mainly to its rich blood supply and the possibility of studying the adrenergic innervation of blood vessels (including vessels of the microcirculation) in total film preparations. Much less attention has been directed to the extravascular regions of the mesentery. Yet it is they, as preliminary observations [5] have shown, which can provide a convenient object for the study of the morphology of autonomic terminal structures. With no contractile or glandular formations, the extravascular regions of the mesentery have a rich adrenergic innervation, the two-dimensional arrangement of which provides favorable conditions for the study of general and special problems of the structural organization of the terminal portions of the autonomic nervous system.

It was this fact which motivated the present investigation in which the adrenergic endings in the mammalian mesentery were studied.

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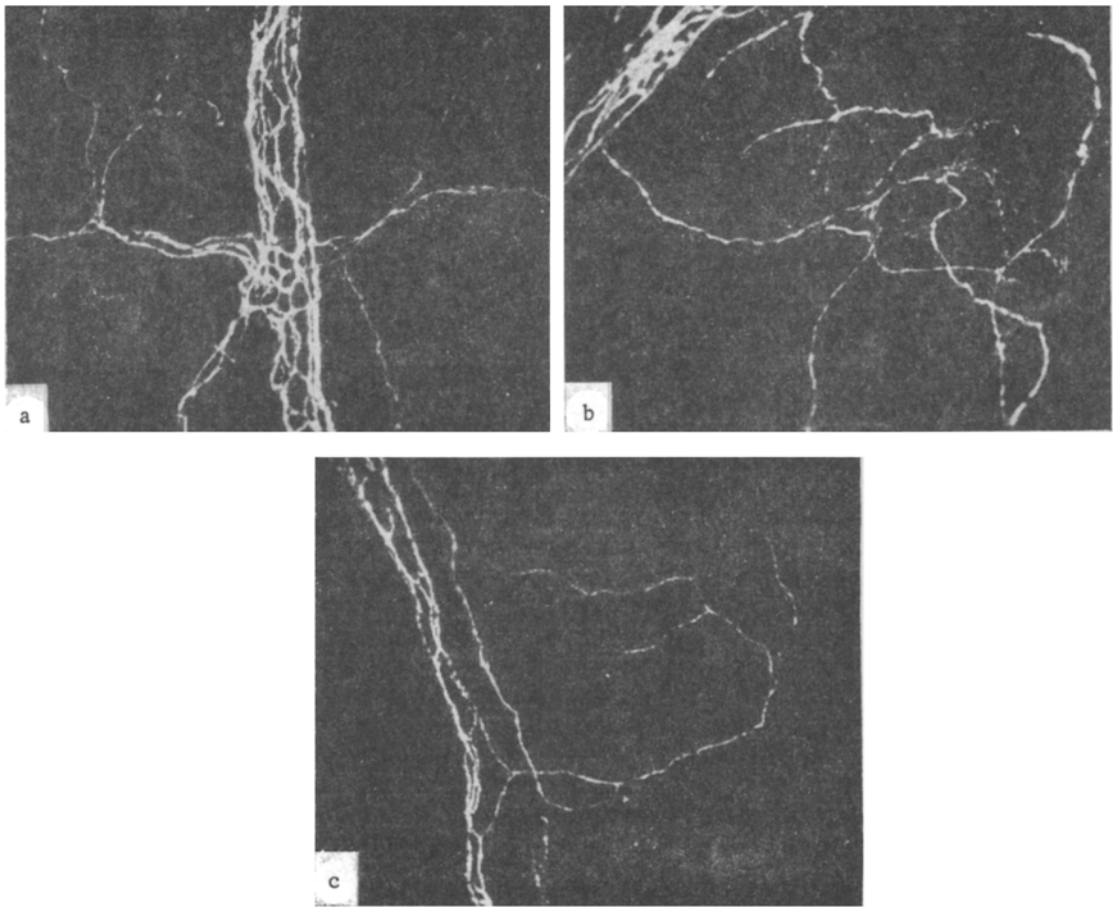

Fig. 1. Variants of adrenergic terminal structures arising from perivascular mesenteric plexuses: a) mesentery of the cat; b, c) mesentery of the dog. Falk–Hillarp method, 450 ×.

EXPERIMENTAL METHOD

The mesentery of sexually mature cats and dogs served as the test object. Total preparations of the mesentery of the small and large intestine, obtained immediately after death of the animals, were used. Adrenergic nervous structures of the mesentery were detected by the Falk–Hillarp method [10] in accordance with the following scheme: 1) stretching out film preparations on clean slides; 2) drying in a jet of air (from a room fan) for 3-5 min; 3) treatment with gaseous paraformaldehyde (relative humidity 51%) for 1.5 h at 80°C or for 3 h at 37°C. The preparations were examined and photographed in the ML-2 luminescence microscope.

EXPERIMENTAL RESULTS

Successive microscopic investigation of total preparations of the mesentery, obtained by the Falk–Hillarp method, showed above all the rich adrenergic innervation of the blood vessels. It was easy to see that the overwhelming majority of adrenergic nerve fibers accompanied arterial segments of the mesenteric vascular system, whereas along the course of the veins they were very few in number or absent altogether. The basis of the adrenergic plexus in the wall of the mesenteric blood vessels was formed by longitudinally arranged fibers, branching frequently along their course with the formation of side collaterals, which intersected the wall of the vessel obliquely or transversely. As a result, along the course of the blood vessels more or less dense and complex arterial networks were formed, in which nerve fibers with varied morphological characteristics could be seen. Some of them, mainly those of larger caliber (about 2 μ), had sufficiently smooth outlines and they stood out in clear contrast because of their intensive and, on the whole, regular luminescence. Thin fibers running alongside them (about 0.5 μ in diameter) mainly contained axons in a varicose state and showed very irregular luminescence. Alternation of intensively luminescent regions along the course of these fibers with regions of sharply reduced or totally absent luminescence gave them a characteristic appearance of broken lines (Fig. 1a).

In different parts of the perivascular plexuses single adrenergic fibers could be seen to emerge from them. Entering the avascular regions of the mesentery, they formed a system of preterminal and terminal branches. Such branches were usually given off by the thickest smoothly outlined fibers which, after a series of dichotomous divisions, were transformed into thin, varicose collaterals; these in turn branched into the thinnest terminals. When tracing the fate of each terminal, it could be seen that some, becoming thinner and losing their fluorescence, became hardly distinguishable against the background of the tissue substrate and appeared to fade away to nothing. Other terminals retained their intensive fluorescence to the most terminal structures, which frequently consisted of enlarged varicose expansions of axons (Fig. 1b). Some terminals also were seen which broke up soon after their appearance into a large number of short terminal twigs resembling brushes or arborizations (Fig. 1c). The observations described above applied equally to animals of both species studied — cats and dogs.

The architectonics of the terminal adrenergic fibers in the avascular regions of the mesentery was thus highly varied, but on the whole it could be characterized as a system of terminal ramifications constructed in accordance with the principle of spreading or localized arborizations. As was to be expected, this structure of the adrenergic terminals is not characteristic exclusively of the autonomic innervation system of the mesentery. Conclusive evidence of this is given in a paper by Govyrin and Bukinich [1], in which similar terminal formations were described in the wall of the renal and splenic veins. These workers described them as "free" adrenergic endings in the form of arborizations. At the same time it must be admitted that such observations are very rare among the many publications describing investigations by the Falk–Hillarp fluorescence-microscopic method. In all probability, terminal formations of this type have not attracted due attention from investigators.

It is easy to see that the adrenergic terminals described above have common structural features with sensory nerve endings and, in particular, with receptors of the "diffuse" type, widely represented in many different organs and tissues. This fact assumes special importance because the possibility of a sensory function of adrenergic nervous structures has been discussed in the literature in recent years [6, 7, 9]. It is suggested that adrenergic terminals located in tissues with no contractile formations may possess this quality. This condition is fully satisfied by the terminal structures of the avascular regions of the mesentery, in which there is in fact no substrate for effector action. However,the writers do not consider it possible to assume a sensory function of any particular part of the adrenergic terminal structures of the mesentery purely on this basis. Irrespective of however justified it may be to distinguish sensory (afferent) components in the adrenergic autonomic nervous system, it must be remembered that the physiological role of its terminal synaptic structures is not limited to a trigger (effector) function. In the zone of distribution of these synapses an active mediator field inevitably is produced, and regardless of the presence or absence of contractile elements, it exerts an effect on the tissue metabolism of the innervated substrate as a whole. The writers are inclined to see in this phenomenon one of the possible mechanisms of the adaptive-traffic influence of the sympathetic nervous system.

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