NEURO-CAPILLARY CONNECTIONS IN THE RAT MYOCARDIUM

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Electron-microscopic investigation of the myocardium of albino rats taken from the apical region of the heart revealed nerve endings in the basement membrane of the endothelial cells and pericytes. The endings contained many smooth synaptic vesicles 450-550 Å in diameter and small dense mitochondria. The width of the space between the ending and the surface of the epithelial cell or pericyte was 1200-1700 Å. The possibility that their axons lying in the pericapillary space may participate in the innervation of microscopic blood vessels is discussed.

Previous electron-microscopic studies have shown that after experimental disturbance of the innervation of organs (lungs, heart) changes in the ultrastructure and permeability of the blood capillaries develop relatively rapidly [1]. This raises the question of how the disturbances of innervation in the zone of the microcirculation and at the capillary wall level are brought about in these organs.

The object of the investigation described below was to study the possible types of connection between the nervous system and capillaries.

EXPERIMENTAL METHOD

Male albino rats weighing 180-400 g were anesthetized with ether and pieces of myocardium taken from the apical region and fixed for 1.5 h in the cold in a 1% OsO_4 solution (pH 7.4) or in a mixture of 1% OsO_4 + 2% paraformaldehyde + 0.5% picric acid (in 0.1-M phosphate buffer, pH 7.2). The tissue was embedded in epoxide resins by the usual method. Ultrathin sections were stained with uranyl acetate and lead citrate and examined in the electron microscope.

EXPERIMENTAL RESULTS AND DISCUSSION

Small nerves and single axons, myelinated and unmyelinated, and partially or completely covered with Schwann cells, were frequently found in the interstices between the muscle fibers and in the pericapillary space, in agreement with the findings observed previously [2]. Their axons, found in the pericapillary space, often contained many microvesicles of synaptic type, located directly beneath the axolemma and often interacting with it. Because of this structure of the bare axons, and also the discovery of extracellular synaptic vesicles near them [4], it can be postulated that they help to regulate the state of structural elements in the pericapillary zone and of the capillaries themselves. This could be an important method of nervous regulation of the capillaries and of complete microcirculatory sites.

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Laboratory of General Pathophysiology and Experimental Therapy, Institute of Normal and Pathological Physiology, Academy of Medical Sciences of the USSR, Moscow. Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 74, No. 12, pp. 96-98, December, 1972. Original article submitted April 25, 1972.

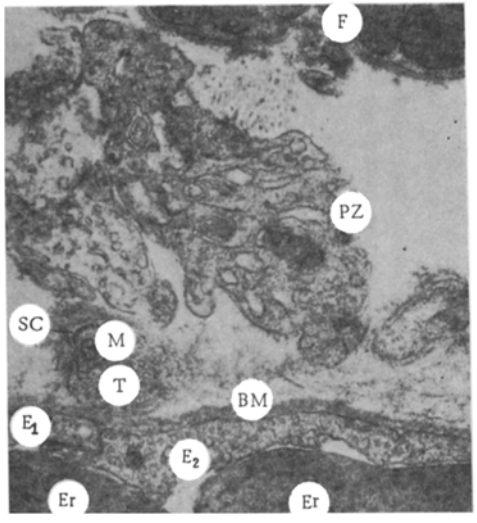

Fig. 1. Nerve ending in blood capillary: E_1 and E_2) endothelial cells; Er) erythrocytes in lumen of capillary; T) terminal; BM) basement membrane; PZ) pericapillary zone; F) muscle fibers; M) mitochondrion; SC) Schwann cell; 21,500×.

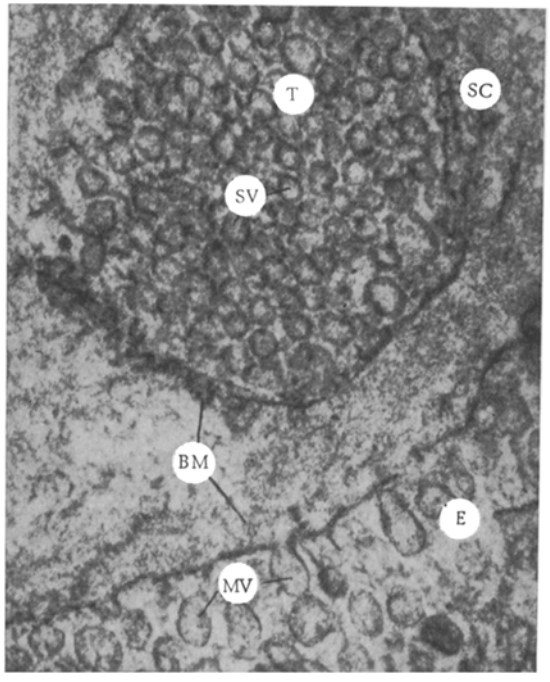

Fig. 2. Nerve ending in endothelium: E) endothelium; T) terminal; BM) basement membrane; SV) synaptic vesicles; MV) micropinocytotic vesicles in endothelial cell; SC) appendage of Schwann cell; 120,000×.

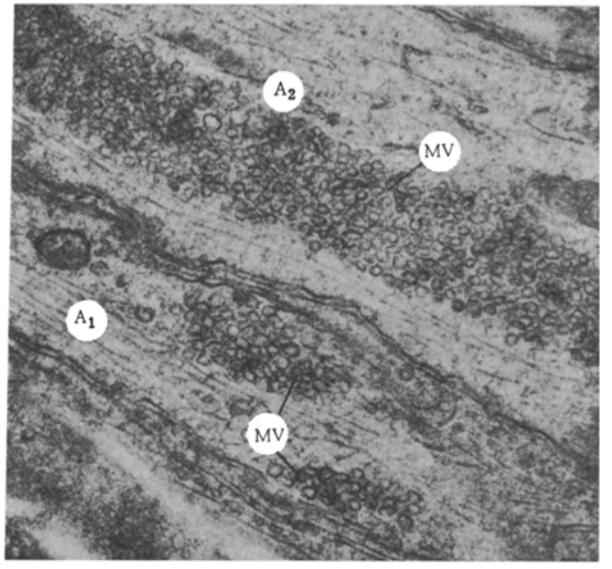

Fig. 3. Unmyelinated nerve fibers in longitudinal section. Axial collections of microvesicles (MV) can be seen. A_1 and A_2: axons; 40,000×.

Examination of the specimens revealed nerve elements also in direct contact with the capillary wall (Fig. 1). These were oval structures with their own basement membrane, fused with the basement membrane of the endothelium (Fig. 2). In the zone of fusion of the basement membranes the distance between the nerve ending and surface of the endothelium was 1200-1700 Å. The endings thus found contained many smooth synaptic vesicles 450-550 Å in diameter. The size of individual vesicles was 1000 Å. The vesicles were surrounded by a triple membrane and their contents were homogeneous. Similar vesicles also were found in the axoplasm of the unmyelinated nerves discovered in the sections (Fig. 3). Small, dense mitochondria (from one to five in each section) were similar with the mitochondria in the axons. Some endings were partly covered by Schwann cells.

Endings of this type were also found near the pericytes. However, contacts with a synaptic space of 100-200 Å, as described in the literature [3], could not be found in this case. Wherever such contacts were found, in serial sections it was clear that the processes in contact with the nerve fiber, which could have been taken as processes of the pericyte, in fact belonged to Schwann cells.

The results thus show that close structural connections exist between the nervous system and the blood capillaries (at least in the myocardium), and in some cases nerve endings are actually found in the endothelium. The fact that these connections are found in the myocardium is important. Further investigations are required to assess the degree of development of these connections and the functional significance as well as the nature of these nerve endings.

LITERATURE CITED

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