# ARRANGEMENT AND RESPONSES OF SMOOTH-MUSCLE FIBERS IN ARTERIAL WALLS IN THE CEREBRAL CORTEX

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Circular muscle fibers in the arteries and arterioles of the rabbit cortex are arranged in groups. With a decrease in the diameter of the arteries, the length of the muscle nuclei is reduced, but not their width. In asphyxia, paroxysmal activity, and a postischemic state of the cortex, the thickness of the muscle fibers increases while the lumen of the vessel is constricted.

The function of the walls of small arteries in regulation of the internal blood supply of an organ is largely determined by the number and arrangement of their smooth-muscle fibers, and by the character of their responses. Whereas in early morphological investigations the general structural features of the media of the small arteries were usually examined without regard to their location in the body, nowadays the study of the media of blood vessels in particular organs is of increasing importance. Only general information on the morphology of the small arteries of the cerebral cortex can be found in the literature [2, 6], and no attempt has been made to study the structural details of their media and the characteristics of its responses.

The object of the present investigation was to study the arrangement and responses of smooth-muscle fibers of small arteries in the cerebral cortex.

## EXPERIMENTAL METHOD

Experiments were carried out on 38 unanesthetized adult rabbits of both sexes, under local procaine anesthesia. Because it is impossible to undertake microscopic observations during life on blood vessels in the cerebral cortex, they were investigated in intravitally fixed (using 6% formalin in a mixture of physiological saline and ethyl alcohol) brain tissue in sections about 30 $\mu$ in thickness [4] and in total preparations. The latter were made as follows: on the 4th-5th day after intravital fixation the membrane was carefully removed from the brain under the MBS-2 binocular microscope, removing along with its vessels from the cortex the radial arteries and their branches extending for about 200-250 $\mu$. The sections and total preparations were investigated both unstained and also after staining with hematoxylin-eosin, by Van Gieson's method, and by silver impregnation. The cortical vessels were studied under the following conditions: control (no treatment), postischemic state (when the blood flow had been restored after its interruption for 1-2 min), paroxysmal activity (after application of 0.5% strychnine solution to the cortex for 30 sec and 5 min), and asphyxia (occlusion of the trachea for 1-2 min).

The arrangement and size of the smooth-muscle fibers in the vessel walls were judged from their nuclei. Their length and width along the whole length of the vessels were measured by means of an ocular micrometer; the results of the measurements were analyzed by statistical methods. The investigated vessels in the cortex were conventionally divided into two groups: arteries 21-40 $\mu$ in diameter and arterioles 10-20 $\mu$ in diameter.

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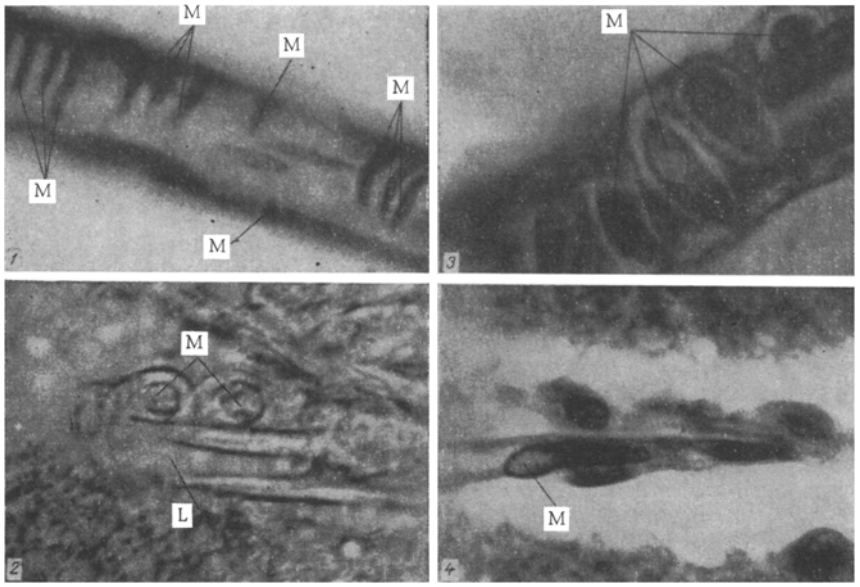


Fig. 1. Arrangement and responses of smooth-muscle fibers of small cortical arteries and arterioles in the rabbit's brain under different conditions: 1) grouped arrangement of nuclei of circular smooth-muscle fibers (M) in wall of a radial artery 25 $\mu$ in diameter (total preparation, hematoxylin-eosin, 400×); 2) morphological changes in smooth-muscle cells (M) during their contraction in wall of arteriole 15 $\mu$ in diameter (L – lumen) in asphyxia (unstained section, 30 $\mu$ in thickness, 900×, retouched photomicrograph); 3) morphological changes in smooth-muscle cells (M) during their contraction in wall of arteries 30 $\mu$ in diameter during paroxysmal activity (total preparation, hematoxylin-eosin, 900×); 4) uneven thickening of nucleus during contraction of smooth-muscle cell (M) in arteriole 12 $\mu$ in diameter during paroxysmal activity. Section 30 $\mu$ in thickness, hematoxylin-eosin, 900×.

## EXPERIMENTAL RESULTS

Nuclei of smooth-muscle fibers were clearly visible in the walls of the arteries in sections and total preparations, both unstained and stained. The media of arteries measuring 21-40 $\mu$ in diameter consists of an outer layer of circular and an inner layer of longitudinal smooth-muscle fibers. The circular smooth-muscle fibers are firmly packed together and form a continuous layer, whereas the inner layer is not continuous: the muscle fibers are scattered throughout the thickness of the media.

With a decrease in diameter of the arteries the circular smooth-muscle fibers gradually diminished in number, so that spaces free from muscles are formed between neighboring cells. In arteries measuring 30 $\mu$ in diameter, for instance, on the average four smooth-muscle fibers are found in the space of 10 $\mu$ along the length of the vessel, compared with mainly three fibers in arteries measuring 20 $\mu$ in diameter, and one or two in arterioles (12-14 $\mu$).

Circular smooth-muscle fibers form groups of three or four cells in which the nuclei are arranged in one row (Fig. 1, 1). These groups of muscle fibers, alternating along the course of the vessel, are found around its lumen on different sides (a similar arrangement of muscle fibers has also been discovered in the small arteries of the mesentery [8]). However, in the precapillary arterioles measuring 10-14 $\mu$ in diameter, this definite arrangement of smooth-muscle fibers is absent. Here only scattered muscle cells arranged either circularly or longitudinally can be found.

The length of the nuclei of the smooth-muscle fibers decreases with a decrease in diameter of the cortical arteries, but there is no change in the width of the nuclei. In arteries 21-40 $\mu$ in diameter, for instance, the length of nuclei of the muscle fibers was $17 \pm 0.4\,\mu$ and their width $3 \pm 0.02\,\mu$, while in arteries 10-20 $\mu$ in diameter their length was $11 \pm 0.63\,\mu$ and their width $3 \pm 0.43\,\mu$ (arithmetic mean values and confidence limits are given).

Responses of the smooth-muscle fibers of cortical arteries fixed intravitally during asphyxia, or postischemic and paroxysmal states, occurred during the first 30 sec after exposure. In longitudinal sections through the vessels, the nuclei of the muscle fibers became circular and they gave the impression of being swollen. Apparently swollen cytoplasm and a clearly demarcated cell membrane could also be seen around the nuclei of the smooth-muscle fibers (Fig. 1, 2). This was seen more clearly still in total preparations (Fig. 1, 3). These changes in the nuclei of the smooth-muscle fibers were found throughout the extent of the cortical arteries as far as the smallest ramifications of precapillary arterioles 10-14$\mu$ in diameter, in which the muscles are mainly arranged longitudinally. Sometimes an asymmetrical increase in thickness of the nuclei of the smooth-muscle fibers was observed: one of their ends was considerably thickened and rounded, while the other remained pointed. These changes in the smooth-muscle fibers led to an increase in thickness of the vessel walls and to a decrease in their lumen. The lumen was frequently uneven, depending on the character of arrangement of the smooth-muscle fibers. For instance, the most thickened places were those parts of the vessel walls where nuclei of the muscle cells were found. This gave the walls of the cortical arteries their unevenly thickened appearance. Changes in the lumen of the cortical vessels arising under these conditions have been described previously by the writers [4, 5].

These changes in the smooth-muscle fibers were evidently the morphological expression of their contraction, because similar changes have been described in other organs during vasoconstriction evoked by adrenalin [1, 7, 8, 9]. Other evidence of contraction of the smooth-muscle fibers under these conditions is the fact that similar changes could be observed very soon (after tens of seconds) after various procedures, and they were always accompanied by constriction of the vascular lumen.

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