MORPHOLOGICAL AND ELECTROPHYSIOLOGICAL FEATURES OF A NEURONALLY ISOLATED STRIP OF UNANESTHETIZED RABBIT CORTEX

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The morphological disturbances of the neurons in the central portion of a neuronally isolated strip of rabbit cortex were shown to be reversible and functional in character up to the second day after operation. Twenty days after isolation degenerative changes appeared in some neurons of the strip. The number of astrocytes stained with silver increased considerably in the strip from the second day after isolation. The isolated cortical strip possesses slow electrical activity and spontaneous discharges can be recorded in its neurons, but this activity differs from the corresponding indices for the intact cortex.

Some workers [13, 17] have not found spontaneous electrical activity in the isolated cortex. Most workers [2-4, 8-11, 15], on the other hand, have recorded activity of this type. The histological changes in the strip have received inadequate study [7, 14].

The object of this investigation was to determine the morphological characteristics of a neuronally isolated strip of cortex 2 h and 2 and 20 days after its isolation.

EXPERIMENTAL METHOD

Neuronally isolated strips (15 mm long, 5 mm wide, about 3 mm deep) of the cerebral cortex of unanesthetized, unimmobilized rabbits were investigated. The method of isolation and recording of slow and spike activity was described earlier [10, 11].

The rabbits were killed by air embolism. The nerve cells were stained by Nissl's method and astrocytes by Cajal's method. At least 3 rabbits were used at each time in the postoperative period. No electrophysiological experiments were carried out on these animals. The central part of the isolated cortex and the symmetrical area of the opposite hemisphere were studied. The technique of cutting the sections and determining the size of the nucleus and cytoplasm of the neurons is described elsewhere [5]. Glial cells were counted by the method described previously [1].

EXPERIMENTAL RESULTS

The sections show (Fig. 1) that isolation of the strip was complete. Two days after the operation there were fewer neurons in the center of the strip than in the symmetrical area of the opposite cortex. Microelectrode studies showed that the number of spontaneously firing neurons in the strip was reduced by 3-4 times compared with the intact cortex.

The mean area of the nucleus of the neurons in the control sections was $30.0 \pm 1.0 \mu$ (Table 1). The mean dimensions of the nucleus of the neurons 2 h after the operation were very slightly reduced both in the strip and at the symmetrical point of the opposite hemisphere. However, this increase did not continue pro-

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TABLE 1. Mean Area of Nucleus and Cytoplasm of Neurons (in μ^2) and Mean Number of Astrocytes in an Area of 30,720 μ^2 of a Frontal Section through the Isolated Strip of Rabbit Cortex and at the Symmetrical Point of the Opposite Hemisphere in the Early after Operation

Time after isolation	Nucleus of neuron		Cytoplasm of neuron		Number of astrocytes	
	strip	symmetrical point	strip	symmetrical point	strip	symmetrical point
2 h	24,1±1,0	25,0±1,0	49,2±2,7	47,7±2,2	9,9±0,4	11,2±0,3
2 days	26,9±1,6	26,3±1,3	46,5±3,6	50,7±3,2	15,4±0,4	18,8±0,4
20 days	23,8±0,9	26,1±1,1	35,1±1,3	56,1±3,0	19,5±0,6	12,7±0,5
Intact cortex.	30,0±1,0		52,9±2,4		9,0±0,5	

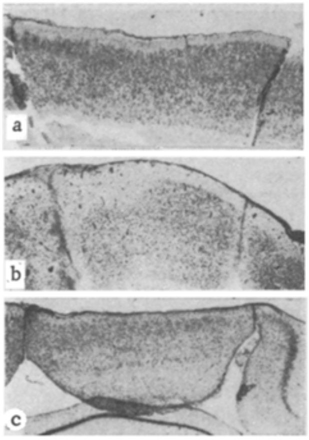

Fig. 1

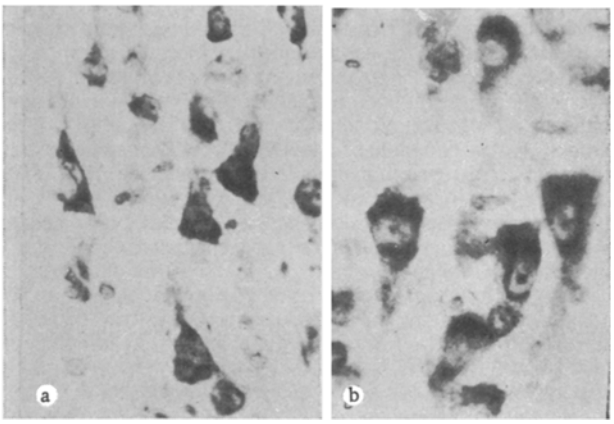

Fig. 2

Fig. 1. Neuronally isolated strip of cerebral cortex of a rabbit 2 h (a) and 2 (b) and 20 (c) days after isolation. Nissl, 15×.

Fig. 2. Neurons in isolated strip of cortex 20 days after isolation (a) and at symmetrical point of opposite hemisphere (b). Nissl's stain, 400×.

gressively with an increase in the postoperative period. The observed decrease in size of the nucleus of these neurons was evidently a nonspecific reaction of the whole brain to mechanical trauma.

The mean area of cytoplasm of the neuron in this strip decreased progressively with an increase in the postoperative period although the difference compared with the intact brain was not statistically significant until 20 days ($P < 0.01$) after isolation. At the symmetrical point of the opposite hemisphere the dynamics at this period was reversed.

The histological picture of the changes in the neurons in the central part of the isolated strip was reversible in character 2 h and 2 days after isolation and corresponded to that associated with functional changes (Fig. 2).

The changes in the cells after 20 days were of a different character, associated with karyocytolysis, with a decrease in the size of the cytoplasm and shrinkage of the cell, although in the central part of the strip many neurons still remained intact.

The results of electrophysiological experiments demonstrated that the basic properties of the neurons were still intact 2 h and 2 days after neuronal isolation of the cortical strip. This applies in particular to spontaneous unit activity. Recordings of spike and slow electrical activity of the strip and intact cortex are

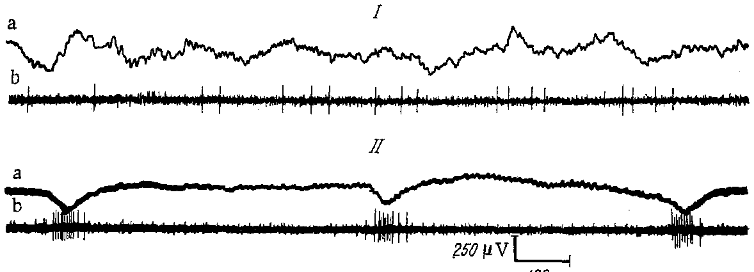

Fig. 3. Slow (a) and spike (b) activity of intact cortex (I) and of intact cortex (I) and of isolated cortical strip 3 after isolation (II).

given in Fig. 3. Clearly the neurons of the strip discharged more frequently (about 5 times) with volleys of spikes. The integral electrical activity of the strip was distinguished by predominance of slow waves and by the presence of "periods of silence." These features were characteristic only of the strip soon after isolation. With an increase in the postoperative period the electrocorticograms (ECoGs) gradually came to resemble the ECoG of the intact cortex although complete identity was not observed for several months after the operation. The ECoG of the strip was considerably inhibited after administration of general anesthetics or muscle relaxants and also after various additional brain sections [10].

The appearance of slow components in the EEG is nowadays often connected with functional activation of the glial elements of the brain [6]. It was therefore decided to examine the character of the changes in the glial cells. As Table 1 shows, 2 h after the operation the number of stained astrocytes in the strip was increased only very slightly. This increase became statistically significant after 2 days ($P < 0.01$), and 20 days after isolation the original number was more than doubled. Some increase in the number of astrocytes was observed at the symmetrical point of the opposite hemisphere 2 h after isolation, but after 2 days this increase was no longer visible, and after 20 days a slight increase in the number of astrocytes compared with the intact cortex was again discerned.

Other workers [17] also have observed an increase in the number of glial elements in the neuronally isolated strip of cortex. In the present experiments no vascular changes either in the strip or at the symmetrical point of the opposite hemisphere were observed 2 h after isolation; hyperplasia of vessels of average caliber and of the precapillaries, together with manifestations of perivenous edema, were observed in the strip 2 days after isolation; no such changes in the vascular system could be found after 20 days. According to data in the literature the ECoG of the strip is largely dependent on its blood supply [15, 16].

After neuronal isolation of a strip of the rabbit's cortex most of the neurons in its center thus remain intact after 2 h and 2 days. The slight decrease in size of the nucleus immediately after isolation and the decrease in area of the cytoplasm only in the late stages after isolation are evidence of functional changes in unit activity. The number of astrocytes is clearly increased after 2 days. This may possibly affect the ECoG of the strip (predominance of slow components) and also the spontaneous spike activity of single neurons (predominance of grouped discharges). Whatever the case, it can be concluded from the morphological integrity of the neurons and the existence of spontaneous (both slow and spike) activity that the neuronally isolated strip of cortex of unanesthetized and unimmobilized animals is a convenient model with which to study many neurophysiological problems.

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