THE SORPTIVE PROPERTIES OF THE CEREBRAL CORTEX DURING GENERAL ANESTHESIA

Z. M. Zhevlakova

Department of Physiology (Head, Professor G. N. Sorokhtin),
Khabarovsk Medical Institute
(Presented by Active Member AMN SSSR V. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 53, No. 4,
pp. 71-74, April, 1962
Original article submitted April 10, 1961

Numerous investigations [11, 13, 14, 15, and others] have shown that the development of sleep under anesthesia is due to blocking of the reticular formation of the brain stem. The problem of the state of the cerebral cortex during various forms of general anesthesia has not yet been solved.

When given as an anesthetic, ether lowers lability and causes cathodal depression, whereas hexabarbital acts in the opposite manner and increases lability, causing anodal depression [1, 2, 6, 7, 9, 12]. Direct measurement of the general level of the polarization potentials of the cerebral cortex in albino mice has shown that in hexabarbital anesthesia a hyperpolarization develops, whereas ether and urethane anesthesia leads to depolarization [10].

S. V. Levin [8] showed by means of the vital staining method that the sorptive properties of the cerebral cortical cells of albino mice are increased by 69.2% during ether anesthesia, and by 64.4% in urethane anesthesia, over control values. In the present paper we examine the sorptive properties of the cerebral cortex during ether and hexabarbital anesthesia.

EXPERIMENTAL METHOD

Experiments were conducted on albino mice by S. V. Levin's method [8]. Under light anesthesia the skull was trephined and the meninges over the frontal and parietal areas of the cortex removed in both control and experimental animals; the animals were then placed in a humid chamber at 33°. The exposed surface of the brain was immersed in Ringer's solution (soda-free), warmed to 36-37°. Thirty minutes after operation, when the action of the ether had passed off, vital staining was performed, using as basic dye a 0.05% solution of neutral red in soda-free Ringer's solution at 36-37°.

TABLE 1. Results During Ether Anesthesia (Exposure for 30 minutes)

Ex 1000 exp.	Ex 1000 control exp.
190	120
200	100
226	123
233	200
266	160
290	193
303	216
190	120
286	196
316	223
$M_e = 250 \pm 15{,}2$	$M_к = 166 \pm 14{,}5$

$$M = +84 \pm 21$$

$$\frac{M_e}{M_к} \times 100 = 150\%$$

In the first series of experiments the experimental mice were anesthetized by means of cotton wool, pressed into the shape of a funnel and soaked in ether. The upper edge of the funnel was placed over the mouse's nose. Slow breathing and absence of defense reflexes indicated complete anesthesia. Ether anesthesia lasted 30 minutes, and throughout this period the exposed areas of the cortex were treated with vital dye. The cortex of the control mice, which were not anesthetized, was also stained for 30 minutes.

In the second and third series of experiments, anesthesia was induced in the experimental mice by subcutaneous injection of hexabarbital, diluted 1:100, in a dose of 2-3 mg (1 mg/10 g body weight). Staining continued for 30 minutes in the second series of experiments and 45 minutes in the third. At the end of staining the brain surface was freed from tissue debris (skin, muscles, meninges, blood clot) accumulating there in the course of staining.

By inserting a corneal trephine, 4 mm in diameter, into the brain for a depth of 5 mm, a piece of brain tissue of standard size was obtained, consisting of the stained grey matter and unstained white matter. The extracted piece

of tissue was immersed in 1.2 ml of 70° alcohol, acidified with 2% sulfuric acid. After 24 hours the alcoholic extracts of the dye extracted from the cerebral cortex were estimated on the FEK-M photoelectric colorimeter. The values of E obtained were multiplied by 1000 and calculated for a layer of thickness 1 cm. The arithmetic mean of the experimental results M_e was expressed as a percentage of the arithmetic mean of the control results M_K: $\frac{M_e}{M_k} \times 100$.

EXPERIMENTAL RESULTS

In the first series of experiments we studied the changes in the sorptive properties of the cerebral cortex in albino mice during ether anesthesia. It can be seen from Table 1 that ether anesthesia increased the sorptive properties of the cortex by 50%. Our results thus agree with those of S. V. Levin [8].

In the second series of experiments we studied the effect of hexabarbital anesthesia on sorption of dyes during exposure for 30 minutes. It can be seen from Table 2 that hexabarbital anesthesia lowered the sorptive properties of the cells of the cerebral cortex by 35.2% compared with the controls.

TABLE 2. Results During Hexabarbital Anesthesia

Exposure 30 min.		Exposure 45 min.	
EX 1000 exp.	EX 1000 control exp.	EX 1000 exp.	EX 1000 control exp.
150	223	243	300
83	203	266	287
90	110	226	297
70	260	266	310
90	103	276	370
106	130	233	230
80	106	233	233
166	83	233	243
80	140	200	237
73	96	200	233
86	127	223	310
103	187		
96	133		
150	316		
110	190		
93	143		
100	177		
166	166		
120	193		
166	267		
$M_e = 109 \pm 7,3$	$M_K = 168 \pm 14,2$	$M_e = 236 \pm 7,6$	$M_K = 277 \pm 10,6$
$M = -59 \pm 15,9$		$M = -41 \pm 13$	
$\frac{M_e}{M_K} \times 100 = 64,8\%$		$\frac{M_e}{M_K} \times 100 = 85,2\%$	

In the third series of experiments the mice also received hexabarbital but staining continued for 45 minutes. It will be seen from Table 2 that after staining for 45 minutes the sorption of neutral red by the cortex fell by only 14.8% compared with the controls.

The question accordingly arose: why, when staining continued longer, did the difference between the figures obtained for the experimental and control animals diminish? We assumed that this decrease was associated with the reduction of the polarization potential of the cortex at the time when the animal came round from hexabarbital anesthesia. Comparison of the results of the second and third series of experiments with the general polarization curve of the cortex constructed from the experimental data of O. P. Minut-Sorokhtina and co-workers [10] confirmed our hypothesis. In Fig. 1 we show the changes in the brain potentials (in mv) in relation to the initial level of polarization, taken as zero. This curve shows that at the 17th minute of hexabarbital anesthesia the hyperpolarization of the cortex reaches its maximum, and stays at this level until the 28th minute, after which the polarization level begins to fall. The sorption of the cortical cells during exposure for 30 minutes is 35.2% less than that of the controls. In later stages the po-

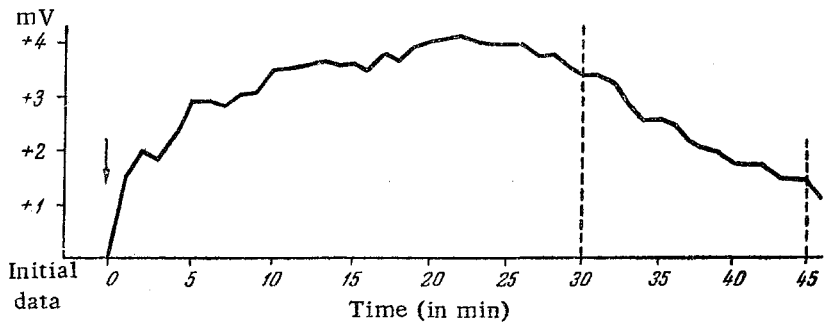

Fig. 1. General polarization curve of the cerebral cortex of albino mice, reflecting the influence of an anesthetic dose of hexabarbital (after the experimental findings of O. P. Minut-Sorokhtina and co-workers [10]). The broken lines indicate the polarization level 30 and 45 minutes after subcutaneous injection of hexabarbital.

larization continues to fall, and during waking it begins to approximate to its initial level. Concurrently, the difference between the sorption of dye by the brain tissue of the control and experimental mice falls to 14.8%.

The data obtained by E. F. Ivanenko and V. F. Dunaeva [4], who investigated sorption after extraction of the brain from the skull, cannot be used to characterize the differences between ether and hexabarbital anesthesia, for in these experiments the cerebral cortex was in a state of depolarization, due to postmortem asphyxia, throughout the period of staining.

Our experimental results, obtained by a different method, confirm the results obtained in G. N. Sorokhtin's laboratory regarding the character of the polarization changes in the cerebral cortex during ether and hexabarbital anesthesia. Ether anesthesia causes the general cortical potential to shift towards depolarization, which is accompanied by a considerable increase in the sorption of dye by the brain tissue. During hexabarbital anesthesia hyperpolarization of the cerebral cortex develops, with a decrease in the sorptive properties of the brain tissue. Attention is drawn to the parallel between the degree of increase of polarization and the level of sorption. With a decrease in polarization, sorption is diminished.

The comparison of the results of our experimental study of the sorptive properties of brain tissue with the results of electrophysiological investigations, undertaken on the same test object, shows that these two methods are complementary and can be used to determine the character of the fundamental functional changes in excitable systems during exposure to various influences.

In this respect it is interesting to note the agreement between G. S. Kovalskii's results [5], showing that hyperpolarization of skeletal muscle develops after denervation, and A. V. Zhirmunskii's results [3] demonstrating a decrease in the sorptive properties of muscle tissue after denervation.

SUMMARY

Intravital staining of the brain tissue indicated that ether anesthesia increased the sorptive properties of the cerebral cortex (hemispheres) in albino mice by 50%, whereas hexenal anesthesia reduced the sorptive properties of the cortical cells by 35.2% as compared to the control. As shown by electrophysiological investigations in G. N. Sorokhtin's laboratory, ether anesthesia causes depolarization, whereas hexenal anesthesia leads to hyperpolarization of the cerebral cortex (hemispheres) in albino mice. Thus, changes in the sorptive properties of the cortical cells coincide with the changes in their polarization level.

LITERATURE CITED

1. L. L. Vasil'ev and N. P. Movchan, In: Problems in the Physiology and Morphology of the Central Nervous System [in Russian], Moscow (1953), p. 51.
2. V. S. Galkin, A Short Account of the Theory of Anesthesia [in Russian], Leningrad (1953).
3. A. V. Zhirminskii, Fiziol. Zh. SSSR (1958), No. 6, p. 577.
4. E. F. Ivanenko and V. F. Dunaeva, Byull. Éksper. Biol. (1956), No. 12, p. 48.
5. G. S. Koval'skii, Fiziol. Zh. SSSR (1960), No. 6, p. 683.
6. M. V. Komendantova, Uchen. Zapiski 2-go Moskovsk. Med. Inst. (1957), 10, p. 141.
7. D. A. Lapitskii, In: Electrotonic Restoration of Physiological Functions [in Russian], Moscow-Leningrad (1937), No. 12, p. 50.
8. S. V. Levin, Byull. Éksper. Biol. (1956), No. 12, p. 50.
9. E. I. Lyublina, Two Types of Action of Organic Solvents (Narcotics) Used in I dustry on the Nervous System [in Russian], Leningrad (1956).
10. I. M. Tylevich, In: Mechanisms of Pathological Reactions [in Russian], Leningrad (1952), No. 21-25, p. 65.
11. E. F. Domino, J. Pharmacol. exp. Ther. (1955), Vol. 115, p. 449.
12. E. E. King, Ibid. (1956), Vol. 116, p. 404.
13. G. Moruzzi and H. W. Magour, Electroenceph. clin. Neurophysiol. (1949), Vol. 1, p. 455.
14. G. Rossi and A. Zanchetti, The Reticular Formation of the Brain Stem. Anatomy and Physiology [Russian translation], Moscow (1960).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
