PASSIVE AND ACTIVE HYPERPOLARIZATION OF THE SALIVARY GLAND

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Having blocked the inflow of stimulating nerve impulses to excitable systems, G. N. Sorokhtin and co-workers [5] observed passive hyperpolarization in the form of atony of the nerve center. They showed that passive hyperpolarization develops in the spinal cord after chordotomy (spinal shock), and in the cerebral hemispheres, optic lobes, sympathetic ganglia, and gastrocnemius muscle after division or reversible blocking of a nerve.

The object of the present investigation was to verify the hypothesis that the salivary glands also react to denervation, like other excitable systems. The effect of sympathectomy and stimulation of the sympathetic nerve on the constant polarization potentials (CPP) and sorption properties of the submaxillary gland of the rabbit was investigated.

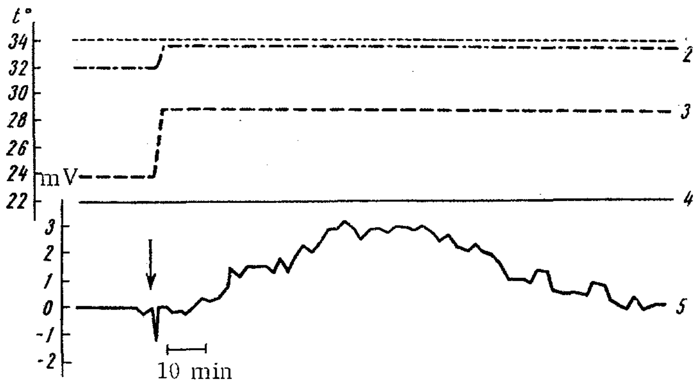

Fig. 1. Effect of removal of the superior cervical sympathetic ganglion on the constant polarization potential of the temperature of the gland and the auricle. 1) Temperature of right gland; 2) of left gland; 3) of left auricle; 4) of right auricle; 5) constant polarization potential. Arrow—moment of gangliotomy.

EXPERIMENTAL METHOD

The submaxillary salivary glands and the left superior cervical sympathetic ganglion were dissected in rabbits lightly anesthetized with ether. The CPP was measured by Sorokhtin's method [5]. The wick of an active nonpolarizing electrode ($Zn + ZnSO_4$) was fixed by means of gelatine to the left submaxillary gland, and the wick of the indifferent electrode to the left tibia, preliminarily stripped of its muscles and its nerve and blood supply interrupted in order to stabilize the potential obtainable from it. Besides the CPP, parallel measurements were made of the temperature of the submaxillary glands and of the auricles on both sides by means of a type TEMP-60 electrothermometer. A study was also made of the changes in the sorption properties of the cells of the gland by the method of Nasonov

TABLE 1. Time and Quantitative Indices of Dynamics of Passive Hyperpolarization

Characteristics of reaction	M	σ	Sm	Standard deviation (for each case)
Latent period (in min)	5.8	4.9	1.03	from -0.77 to +2.08
Magnitude of hyperpolarization (in mV)	4.0	1.82	0.47	from -0.27 to +1.90
Duration of hyperpolarization (in min)	132	76.5	20.4	from -0.05 to +2.32

and Aleksandrov [3]. The glands were stained in situ. Short glass tubes with specially bent edges were glued to the surface of the gland with gelatine, and into the tubes was poured a 0.05% solution of neutral red. Staining continued for 30 min. The glands were then freed and washed with Ringer's solution. Pieces of uniform size were excized from the stained areas of the glands and placed in 70° acidified alcohol to extract the dye. The concentration of dye in the extracts was determined 24 h later by means of a type FEK-M photoelectric colorimeter. The values of the relative content of dye (E) thus obtained were multiplied by 1000 and reduced to a layer thickness of 1 cm.

EXPERIMENTAL RESULTS

When a constant level of CPP had been established in the left submaxillary gland, the left superior cervical sympathetic ganglion was removed (complete removal was verified by the change in the temperature of the left auricle and left gland). Immediately after gangliotomy the temperature of the auricle on the side of the operation rose by 5-10°, and that of the gland by 1-2°. On the opposite side of the head the temperature was unchanged. At the moment of removal of the ganglion a discharge of impulses due to wounding was observed in the form of temporary depolarization to the extent of up to 1.5 mV, after which the CPP reached its initial level. Subsequently, in 15 of 20 experiments after gangliotomy hyperpolarization developed, in 2 experiments depolarization developed, and in 3 the CPP remained unchanged. In the typical experiments in which gangliotomy evoked passive hyperpolarization, we observed a constant increase in the CPP with a plateau in the middle of the curve and a gradual fall to its original level (Fig. 1). Passive hyperpolarization developed 2-16 min after gangliotomy and lasted between 50 and 310 min, reaching 1.7-7.5 mV. These results were analyzed statistically (Table 1).

TABLE 2. Sorption of Dye by Salivary Gland after Denervation

Control	Experiment
E×1000	
1470	970
1400	840
2070	700
1320	860
1800	1000
1900	920
1200	1410
1900	1200
1510	900
1400	930
1498±99	973±62

In the experiments of series 2, after gangliotomy in the presence of established passive hyperpolarization, the gland was stained by the method already described. The gland on the opposite side served as a control. It is clear from the results given in Table 2 that the sorptive power of the cells of the sympathectomized gland was 35% less than that of the control. The decrease in sorption of the dye against the background of simultaneous hyperpolarization, despite the increase in temperature, evidently indicates some thickening of the cell membranes of the gland.

The results of our experiments are in agreement with those obtained by A. V. Zhirmunskii [2] and A. D. Pshedetskaya [4], who demonstrated a decrease in the sorptive power of muscles after denervation, and with those of Z. M. Zhevlakova [1], who found that during passive hyperpolarization of the cerebral cortex due to hexobarbital anesthesia the sorption of dye was reduced.

In the 15 experiments of series 3, the cervical part of the left sympathetic trunk was stimulated with an interrupted current and observations were made on the CPP of the submaxillary gland on the ipsilateral side and on the temperature of the gland and of the auricles on both sides. In each individual experiment a frequency of rectangular impulses (voltage 30 V, duration 10 msec) was chosen which allowed the CPP to be modified in the direction of either hyperpolarization or depolarization. Impulses of lower frequency (10-20 cps) acting for 5 min caused active hyperpolarization of the salivary gland, reaching 2-6 mV and continuing for 26-94 min. More frequent impulses (20-40 cps) caused depolarization. Stimulation of the sympathetic trunk was always accompanied by a transient lowering of the temperature of the auricle and gland on the ipsilateral side. This fall in temperature was also observed at the optimal frequency causing hyperpolarization (Fig. 2).

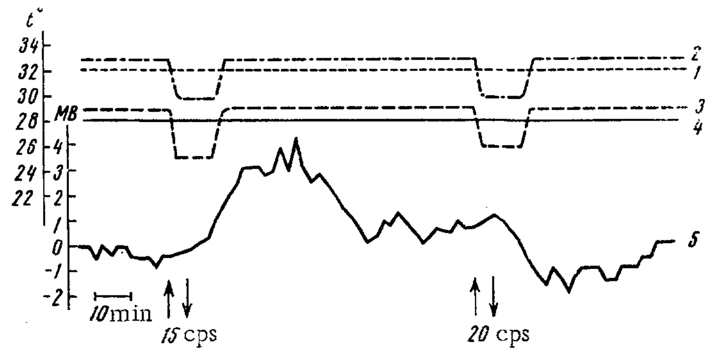

Fig. 2. Effect of stimulation of sympathetic nerve on CPP of salivary gland and temperature of gland and auricle. Arrow pointing upward—beginning of stimulation, arrow pointing downward—end. Remainder of legend the same as in Fig. 1.

SUMMARY

Submaxillary glands were studied in rabbits, following excision of the superior cervical sympathetic ganglion, by the method of estimation of constant polarization potential elaborated by G. N. Sorokhtin, vital tissue staining by D. N. Nasonov and V. Ya. Alexandrov's method and by electrothermometry. This produced passive hyperpolarization, a rise in temperature and a decline in the cellular sorptive activity. Following brief stimulation of the sympathetic nerve by an intermittent current, active hyperpolarization and a fall of temperature were observed in the gland.

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