EFFECT OF STRYCHNINE ON MUSCLE RECEPTORS OF COLD-BLOODED ANIMALS

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The functional state of the muscle receptors was studied in experiments on frogs by recording the spontaneous afferent impulse flow and that evoked by stretching the gastrocnemius muscle in the peripheral portion of the divided sciatic nerve or in dorsal roots IX-X of the spinal cord. Strychnine, if injected into the general circulation or applied directly to the muscle, reduced spike generation in the muscle receptors, but if applied to the spinal cord, it increased spike generation.

Key words: strychnine; muscle receptors.

Details of experiments to study the effect of strychnine on spontaneous and evoked activity of muscle receptors are described below.

EXPERIMENTAL METHOD

Experiments were carried out on frogs (Rana temporaria) with the brain and spinal cord intact. Receptor activity was studied in the gastrocnemius muscle, as reflected in the afferent impulse flow arising spontaneously and evoked by stretching the muscle, and recorded in dorsal roots IX-X of the spinal cord or in the peripheral segment of the divided sciatic nerve. Potentials were recorded by air-filled silver electrodes with interelectrode distance 3-5 mm. The muscle receptors were stimulated by stretching the gastrocnemius muscle with a load of 50 g or by means of a special device stretching the muscle at a standard speed for 1 min. Evoked afferent activity was recorded 10, 20, and 60 sec after the beginning of muscle stretching. The mean number of spikes per second was calculated from the records of unit activity and their mean amplitude determined. The results were subjected to statistical analysis.

Strychnine (0.1% strychnine nitrate) was administered, depending on the object of the experiment, by injection into the submandibular lymph sac (1 ml) or applied (filter paper soaked with 0.1% strychnine solution) directly to the spinal cord or gastrocnemius muscle.

EXPERIMENTAL RESULTS

Three series of experiments were carried out: I) with strychnine injected into the general circulation (lymph sac), II) with strychnine applied to the gastrocnemius muscle, and III) with strychnine applied to the spinal cord.

In the experiments of series I the sciatic nerve (or dorsal roots IX-X of the spinal cord) was divided unilaterally before the injection of strychnine, so that after its injection no spasms developed in the muscles on the same side; the afferent impulses recorded before the injection of strychnine served to reflect the original functional state of the receptors.

The experiments of this series showed (Table 1, Fig. 1A, B) that the flow of spontaneous and evoked afferent impulses from the muscle receptors diminished after administration of strychnine and that the de-

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TABLE 1. Effect of Strychnine on Parameters of Spontaneous and Evoked Afferent Impulse Activity from Muscle Receptors

Series of experiments	Experimental conditions	No. of expts in series	Parameter studied	Before procedure: Spontaneous	Before procedure: Evoked by muscle stretching 10 sec	Before procedure: Evoked by muscle stretching 20 sec	Before procedure: Evoked by muscle stretching 60 sec	After procedure: Spontaneous	After procedure: Evoked by muscle stretching 10 sec	After procedure: Evoked by muscle stretching 20 sec	After procedure: Evoked by muscle stretching 60 sec
I	Strychnine injected into lymph sac; impulses recorded in sciatic nerve; duration of spasms 10 min	12						In nerve divided after administration of strychnine			
			Frequency of activity (spikes/sec)	128± 11,8	257± 26,7	228± 18,3	194± 21,1	49± 11,0	156± 25,7	146± 22,8	114± 24,9
			Amplitude of spikes (in μV)	13,3± 1,6	19,6± 1,9	18,7± 1,8	18,1±1,5	13,7± 2,0	16,3± 1,4	15,5± 0,9	14,1± 1,17
								In nerve divided before administration of strychnine			
			Frequency of activity (spikes/sec)					99,1± 11,2	297± 24	185± 19,1	112± 18,8
			Amplitude of spikes (in μV)					14,1± 1,3	17,5± 1,2	18,2±1,1	16,9± 1,4
II	Strychnine injected into lymph sac; impulses recorded in sciatic nerve; duration of spasms 2 min	6	Frequency of activity (spikes/sec)	154± 19,9	286± 33,7	240± 36,5	200± 20,3	115,0± 1,7	250± 40,8	228± 39,4	113± 27,7
			Amplitude of spikes (in μV)	—	—	—	—	—	—	—	—
III	Strychnine injected into lymph sac; impulses recorded in dorsal roots IX-X; duration of spasms 10 min	5	Frequency of activity (spikes/sec)	112± 243	276± 44,3	247± 31,7	200± 19,6	95± 14,3	181, 6± 49,1	140± 57,2	116,2± 45,7
			Amplitude of spikes (in μV)	24,5± 10	24,5± 10,5	22,3±7,2	19,6± 8,0	19,8± 8,0	21,8± 8,0	17,7± 7,0	17,7± 7,0
IV	Application of strychnine to spinal cord; impulses recorded in dorsal roots IX-X 10 min later	12	Frequency of activity (spikes/sec)	240± 22	416± 54,5	386,6± 49,2	297± 47,4	267± 32,5	386,6± 58,0	390± 15,5	335± 31,8
			Amplitude of spikes (in μV)	20,5± 1,1	24,5± 1,8	25,3± 1,6	23,5± 1,3	20,6± 1,06	23,4± 2,3	26,0± 1,8	24,3± 1,3
V	Application of strychnine to gastrocnemius muscle; impulses recorded in dorsal roots IX-X 10 min later	7	Frequency of activity (spikes/sec)	392,8± 46,3	556,4± 25,2	544,2± 36,8	465,7± 37,9	297,8± 43,3	577,1± 42,3	473,5± 62,1	400± 61,8
			Amplitude of spikes (in μV)	27,3± 2,0	30,1± 3,3	33,5± 3,5	31,4± 3,0	29,4± 3,0	37,0± 2,8	26,2±2,7	36,7± 3,3

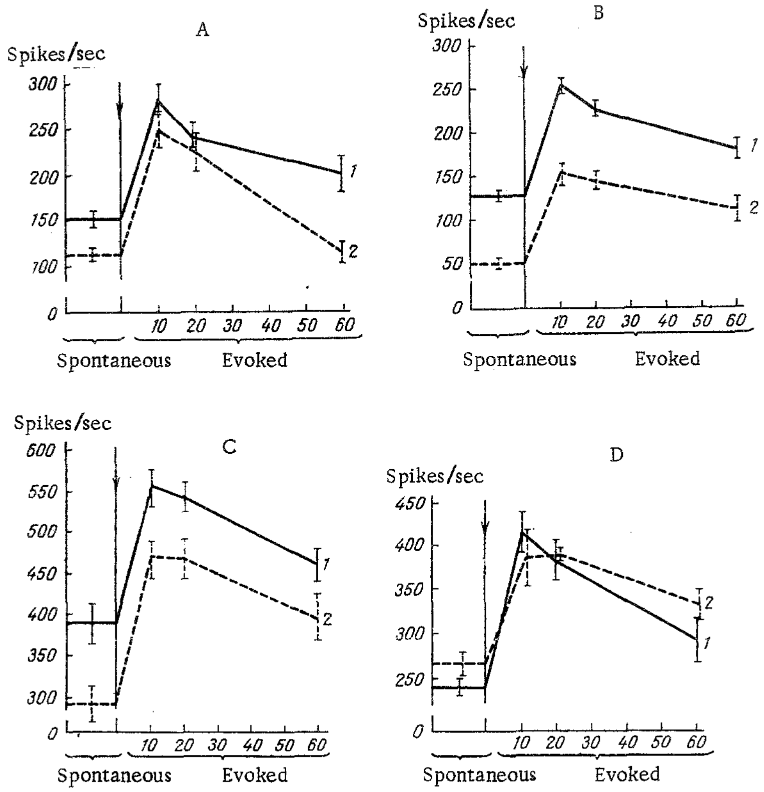

Fig. 1. Effect of strychnine on frequency of spontaneous and evoked afferent impulses from muscle receptors. A and B refer to 2 and 10 min respectively after injection of strychnine into lymph sac; C and D refer to 10 min after application of strychnine to gastrocnemius muscle and spinal cord respectively; 1) before, 2) after injection of strychnine. Arrow marks beginning of muscle stretching.

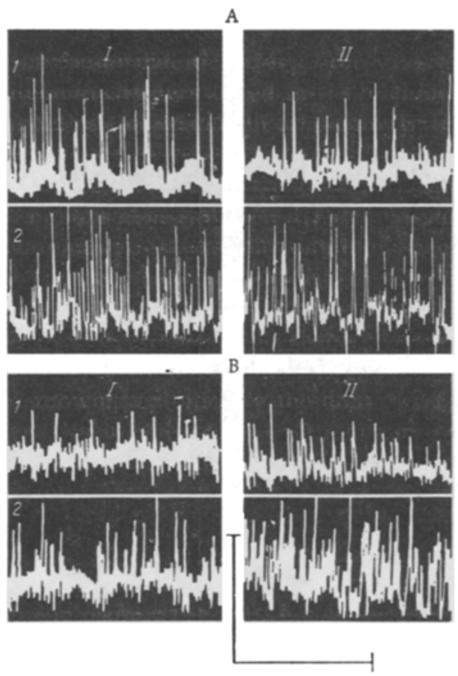

Fig. 2. Spike activity in dorsal roots IX-X of spinal cord before (I) and after (II) application of strychnine to muscle (A) and spinal cord (B): 1) spontaneous, 2) evoked afferent activity. Calibration signal: 50 μV, 0.02 sec.

crease was much greater from those muscles in which paroxysmal activity was observed. The longer the spasms, the greater the decrease in the frequency and amplitude of the recorded impulses.

Application of strychnine to the gastrocnemius muscle, as well as its injection into the lymph sac, was followed by a decrease in the flow of afferent impulses from the muscle into the CNS (Table 1; Figs. 1C and 2A).

In the experiments in which strychnine was applied to the spinal cord the opposite effect was obtained (Table 1; Figs. 1D and 2B); the flow of afferent impulses from the muscle was increased and not reduced.

In all the experiments the frequencies of spontaneous and evoked impulses showed statistically significant changes but the changes in their amplitude were not significant.

The results indicate that administration of strychnine has an effect on the functional state of the muscle receptors manifested as a decrease in their frequency of generation of both spontaneous and evoked afferent impulses and that this effect takes place by several pathways.

One cause of the change in the functional state of the muscle receptors is the occurrence of muscle spasms. This is confirmed by the fact that after administration of strychnine, spike generation in receptors of muscles in a state of tetanic spasm was reduced by a much greater degree than in the receptors of muscles not in spasm and also by the fact that the degree of decrease in receptor activity depends on the duration of the spasms. The results are in agreement with data in the literature concerning the effect of muscular activity and, in particular, of fatigue of a muscle on the functional state of the receptors located in it [1-3].

Strychnine has a direct action on muscle receptors, as shown by the reduction in the flow of afferent impulses from the muscles in which the development of strychnine spasms was prevented by preliminary division of the nerves to the muscle, and also by experiments in which strychnine was applied directly to the muscle. The result of the direct action of strychnine on the receptors, like the result of paroxysmal muscular activity, is a worsening of the functional state of the muscle.

Finally, strychnine affects muscle receptors also via the CNS. Muscle receptors have been shown to be subordinated to central effects [5, 7, 8]. As a drug which blocks inhibitory synapses [4, 6, 9-11], strychnine modifies the character of these effects. Since application of strychnine to the spinal cord in the present experiments led to an increase in both spontaneous and evoked receptor activity, the inhibitory neurons of the spinal cord can be considered to have an inhibitory action on muscle receptors.

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