EFFECT OF ANTIDROMIC IMPULSES OF THE AFFERENT FLOW IN THE A_δ FIBERS OF A CUTANEOUS NERVE

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Afferent activity in myelinated A_δ fibers was analyzed by a modified colliding impulses method. Frequency characteristics of the orthodromic flow without preliminary electrical stimulation of A_δ fibers and after stimulation of the nerve were compared. Antidromic impulses arising during electrical stimulation of the nerve were found to produce an increase in the spike frequency in the afferent flow during adequate stimulation of the skin receptors.

KEY WORDS: *skin receptors; antidromic impulses; afferent flow.*

Electrical stimulation of a nerve evokes both an orthodromic and an antidromic spread of excitation along nerve fibers. Depending on the parameters of electrical stimulation the antidromic spikes may have different effects on orthodromic activity in afferent fibers [1, 11].

Low-frequency stimulation, sufficiently strong to excite myelinated and unmyelinated fibers, either has no significant effect on the activity of receptors [10, 11], or it increases their excitability [1, 4]. An increase in the frequency of antidromic stimulation leads to a marked decrease in receptor activity [1, 11]. Stimulation of a nerve, during which antidromic spikes spread only along myelinated fibers, has no significant effect on orthodromic activity [5].

Antidromic spread of impulses along afferent fibers is also observed during adequate stimulation of receptors [1, 3, 8, 9]. In that case, impulses from one receptor can spread antidromically along branches of the nerve fiber and regulate the afferent flow. To understand the mechanism of the coding of information at the periphery it is therefore essential to know how antidromic impulses in each group of afferent fibers affect their orthodromic activity.

In this investigation the effect of electrical stimulation of a nerve on subsequent orthodromic activity in A_δ fibers from skin receptors in cats was investigated.

EXPERIMENTAL METHOD

Cats were anesthetized with hexobarbital (250 mg/kg, intramuscularly). The common trunk of the saphenous nerve was dissected in the region of the inguinal fold and placed on platinum stimulating electrodes. Conduction along the nerve was interrupted proximally to the stimulating electrodes.

The receptive field for testing was on the medial surface of the lower third of the leg. The branch of the saphenous nerve innervating the receptive field was separated from surrounding tissue at the point where it leaves the common trunk and placed on recording electrodes connected to the input of an ac amplifier. The dissected regions of the nerve were flooded with warm mineral oil.

The receptors were stimulated by stroking the skin with a squirrel hair brush. The speed of movement of the brush was 3 cm/sec and the pressure of the bristles of the brush

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Fig. 1. Integral afferent activity in the medial branch of the saphenous nerve. 1) Spontaneous activity; 2) evoked activity during stimulation of receptors by stroking skin with brush; 3) the same, but after preliminary electrical stimulation. Calibration: 25 μV, 100 msec. Arrow marks initial moment of stimulation of receptors.

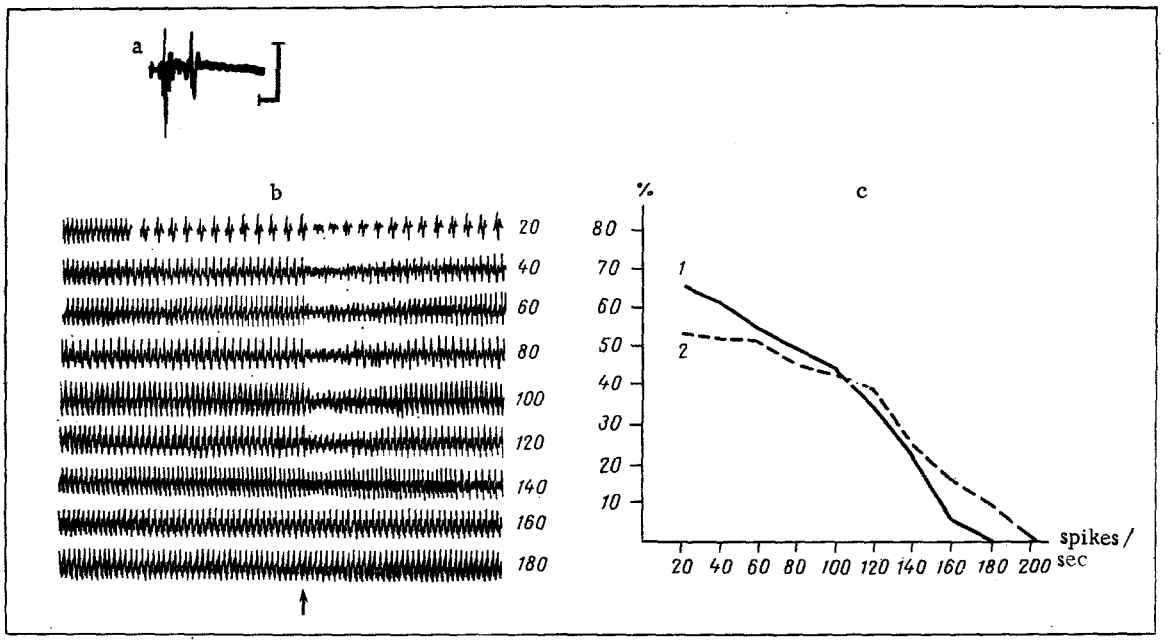

Fig. 2. Characteristics of afferent spike flow in A_δ fibers during stimulation of skin receptors. a) Evoked potentials of $A_{\beta\delta}$; calibration 250 μV, 2 msec, b) Change in amplitude of potential of A_δ fibers during stimulation of nerve at 20 to 180 pulses/sec and stimulation of receptors by stroking skin with brush; arrow marks initial moment of stimulation of receptors. c) Cumulative curves of number of active A_δ fibers relative to frequency of afferent spikes during stimulation of skin receptors: 1) cumulative curve during stimulation of receptors by stroking skin with brush; 2) the same, but after preliminary electrical stimulation of nerve. Abscissa, frequency of nerve stimulation (spikes/sec); ordinate, percentage of active fibers.

on the skin was 120 mg/mm^2. Electrical stimulation of the nerve was carried out by square pulses whose amplitude and duration were chosen to be maximal for excitation of A_δ nerve fibers.

Two series of experiments were performed. In series I the effect of preliminary electrical stimulation of A_δ fibers on the integral afferent activity of a branch of the nerve, recorded during stimulation of the receptors, was investigated. Electrical stimulation was applied 1 sec before afferent activity was recorded. The frequency of stimulation varied from 20 to 200/sec and the duration of the volley from 0.2 to 30 sec.

In series II the number of active A_δ fibers and the spike frequency in them were determined during stimulation of the receptors 1 sec after the preliminary electrical stimulation of the nerve or without it. Electrical stimulation was applied for 1 sec at a frequency of 200/sec.

The afferent flows were analyzed by a modified colliding impulses method [2].

The activity in the nerves and action potential of the A_δ fibers were recorded from the screen of a cathode-ray oscilloscope. A special blind covered the screen so that only the potential of the A_δ fibers was recorded on the photographic film.

The total number of experiments was 17.

EXPERIMENTAL RESULTS

The results of the experiments of series I show that the orthodromic activity changed only slightly after the antidromic spike discharge evoked by electrical stimulation of the nerve (Fig. 1). The change was expressed as a decrease in the number of high-amplitude spikes in the record of the evoked response in the nerve.

With an increase in the frequency of electrical stimulation and in the number of antidromic spikes the changes in the record of the response of the nerve to stimulation of the receptors became clearer. Preliminary electrical stimulation with a frequency of 200/sec and a duration of 1 sec had the greatest effect on afferent activity in the fibers (see Fig. 1, part 3).

However, the integral neurograms give no idea of the changes taking place in individual groups of fibers. Afferent activity in A_δ fibers was therefore analyzed by the colliding impulses method. In this series electrical stimulation with a frequency of 200/sec, causing the greatest change in orthodromic activity, was used (Fig. 1, part 3). Its frequency 1 sec after the beginning of electrical stimulation was reduced in a step to 20-180/sec, after which the skin was stroked with the brush. Under these circumstances an antidromic potential was recorded in A_δ. Its amplitude was reduced on collision with orthodromic impulses from the receptors. The higher the frequency of antidromic stimulation, the smaller the changes in amplitude of the antidromic potential (Fig. 2b).

A cumulative curve showing how the number of active fibers depends on the frequency of antidromic stimulation was plotted from the results of the measurement [2]. This curve was compared with that without preliminary electrical stimulation.

Comparison of the curves (Fig. 2c) shows that the number of active A_δ fibers with low frequencies of spike discharge (from 20 to 100/sec) decreases after the action of the antidromic spikes, and the number of fibers with higher frequencies (from 120 to 200/sec) was correspondingly increased. The total number of active A_δ fibers remained unchanged. This suggests that after the action of the antidromic spikes on the receptors the frequency of orthodromic activity in the afferent fibers increased in response to adequate test stimulation.

A similar increase in the frequency of responses of receptors to adequate stimulation was observed by Horch and Burgess [7] after preliminary mechanical stimulation of the skin.

The mechanisms of the increase in the frequencies of the afferent response after preliminary antidromic or mechanical stimulation are not yet clear. In all probability in both cases there is an increase in the excitability of the ultimate terminal of the nerve fiber. Subsequent adequate stimulation therefore evoked a slight discharge with higher frequency in the fibers.

Meanwhile, despite the increase in spike frequency, total activity in the A_δ fibers was reduced after electrical stimulation (Fig. 1, part 3).

In all probability, it is possible to interpret this as either a reduction of the activity of the A_β fibers, responsible for the great majority of high-amplitude spikes, or by a decrease in the number of coincidences between spikes in the afferent flow. This last event can be explained on the grounds that antidromic impulses bring the receptors into a state of equal "preparedness" for the acting stimulus [6]. In that case the mechanical stimulus excites them simultaneously. However, since the receptors lie at different distances from the recording electrodes, the nervous impulses reach them at different times. Probability of coincidence of spikes from different receptors in that case will be less than after asynchronous excitation of the receptors, and the number of high-amplitude combined spikes in the recorded response will be correspondingly smaller.

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INTRAVASCULAR PRESSURE AND SPONTANEOUS CONTRACTION OF THE LYMPHATICS

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Relations between spontaneous contractile activity and the level of the intravascular pressure were studied in isolated segments of lymphatics. Spontaneous contractions arise when the pressure is of the order of 0.5-1.5 cm water. With an increase in pressure up to 5 cm water the frequency and amplitude of the contractions increase, but when the pressure is 10 cm water they decrease. The indices of the spontaneous rhythm of the lymphatics change not only with absolute values of the intravascular pressure, but also with the rate of their change.

KEY WORDS: *lymphatics; spontaneous contractions; intravascular pressure.*

The lymphatics of warm-blooded animals possess spontaneous rhythmic activity [1-6] which plays an important role in the movement of lymph. A special place among the factors which change the character of the spontaneous contractile activity of the lymphatics is the initial length of the smooth-muscle cells of their wall. Spontaneous contractions of isolated segments of the vessels do not arise in the absence of initial stretching [1-3, 6], and *in vivo* the frequency of pulsation of the lymphatics is connected with the volume of lymph flowing along them [4].

The object of this investigation was to study relations between spontaneous contractile activity and the level of the intravascular pressure in the lymphatics.

EXPERIMENTAL METHOD

Spontaneous contractions of the afferent lymphatics of the mammary glands of goats and sheep aged 2-5 years were recorded. Segments of the vessel measuring 1.5-2 mm in diameter and 8-10 mm in length, corresponding to 1/2-2/3 of a lymphangion [1-3, 6] were isolated. A cannula 1-1.5 mm in diameter, filled with Krebs' solution, was introduced into one end of the lymphatic and the other end tied and connected to a mechanoelectrical transducer of the 6MKh1B type. The preparation was kept in a chamber containing running oxygenated Krebs' solution at 37°C and pH 7.3. The cannula was connected through a three-way tube to a microsyringe with graduated step (by means of which the intravascular pressure changed) and a water manometer to record the pressure. Spontaneous contractile activity was

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