ELECTROPHYSIOLOGICAL CHARACTERISTICS OF FIBERS OF THE SUPERCILIO-AURICULARIS MUSCLE OF THE RABBIT

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Electrophysiological characteristics of fibers of the supercilio-auricularis muscle of a rabbit anesthetized with urethane were investigated by intracellular recording. Square pulses (5 msec, 5/sec) were applied to the muscle fibers. The resting membrane potentials, amplitudes and durations of the action potentials, and their latent periods had mean values typical of muscle fibers of the phasic type. It is concluded that the fibers of this muscle are practically homogeneous and belong to the phasic type.

KEY WORDS: phasic muscle fibers; membrane potentials.

The existence of specialized tonic fibers in vertebrate skeletal muscle was initially postulated on the basis of morphological facts [4]. Proof of the existence of tonic fibers in the skeletal muscle of amphibians was obtained only as a result of later physiological investigations [1, 2, 12], and their more important properties were described. Similar tonic fibers were then found and studied in the ocular muscles of rabbits and cats [6, 7, 11] and in the intrinsic auricular muscles of cats [10, 13]. No such fibers have been found in the skeletal muscles of mammals [8]. It could be postulated that other motor systems serving the sense organs [3] in mammals contain special tonic muscle fibers. In particular, such an hypothesis could be put forward for the muscles of the external auricle, which are in a state of permanent tone [5]. However, the global EMG of the extrinsic auricular muscle has no obvious features on activity of specialized tonic units [5, 9]. Nevertheless, it is impossible to rule out the presence of muscle fibers on tonic type in the extrinsic auricular muscles of mammals purely on the basis of the global EMG.

The object of the present investigation was to study the electrophysiological characteristics of the muscle fibers of an extrinsic auricular muscle of the rabbit and to ascertain whether they are tonic or phasic in type.

EXPERIMENTAL METHOD

Rabbits were anesthetized intravenously with urethane (0.7 g/kg body weight). The supercilio-auricularis muscle (moving the auricle forward) was dissected after local infiltration of the skin with 0.5% procaine solution. The muscle fibers were stimulated by square pulses 5 msec in duration with a frequency of 5/sec. A disc of foil was used as the anode and a needle electrode as the cathode; the stimulating electrodes were applied to the muscle from the outside. Potentials were recorded intracellularly by glass microelectrodes filled with 3 M KCl solution. The stimulating and recording electrodes were so placed that the loop of the stimulus was minimal (Fig. 1a). The values of the resting membrane potential (MP) and the amplitude, duration, and latent period (LP) of the action potential (AP) were estimated. The results were subjected to statistical analysis.

EXPERIMENTAL RESULTS

The electrophysiological characteristics of 162 fibers of the supercilio-auricularis muscle of rabbits were studied. As the microelectrode was inserted into the fiber a resting membrane potential could be de-

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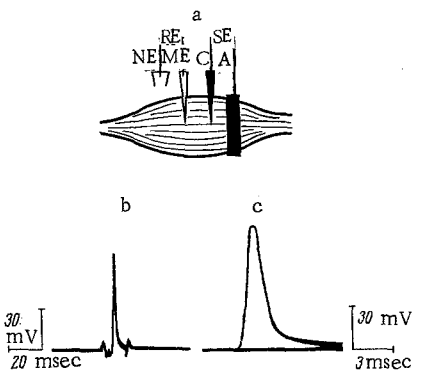

Fig. 1

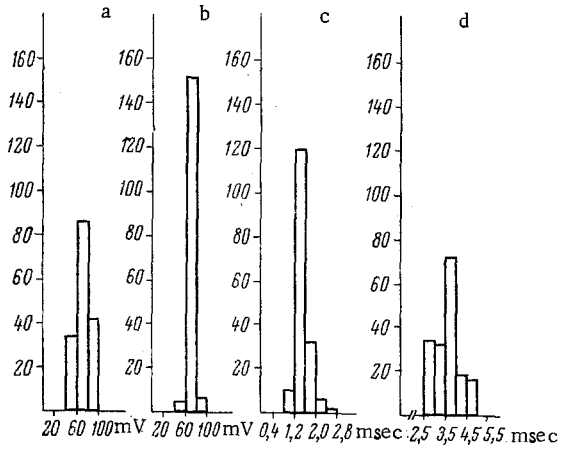

Fig. 2

Fig. 1. Arrangement of stimulating and recording electrodes (a) and examples of action potentials (APs) of muscle fibers of the supercilio-auricularis muscle recorded on loop oscillograph (b) and cathode-ray oscilloscope (c): SE) stimulating electrodes; A) anode; C) cathode; RE) recording electrode; ME) microelectrode; NE) neutral electrode.

Fig. 2. Distribution of electrophysiological parameters of fibers of the supercilio-auricularis muscle: a) membrane potentials ($\overline{X} = 66 \pm 3.9$ mV; $\sigma = \pm 2.6$ mV = 39% of $\overline{X}$); b) amplitudes of APs ($\overline{X} = 72 \pm 0.6$ mV; $\sigma = \pm 8.2$ mV = 11% of $\overline{X}$); c) durations of AP ($\overline{X} = 1.51 \pm 0.001$ msec; $\sigma = \pm 0.23$ msec = 15% of $\overline{X}$); d) latent period of AP ($\overline{X} = 3.66 \pm 0.07$ msec; $\sigma = \pm 0.95$ msec = 26% of $\overline{X}$). Abscissa, parameters named for classes; ordinate, number of variants in each class. Artefact of square pulse produced by current in external circuit not included in amplitude of resting membrane potentials.

tected without any features of spontaneous activity. The appearance of activity (marked APs with "overshoots") was observed in response to electrical stimulation of the muscle. To judge from the ratio of the distances between the electrodes and the latent periods of the APs, stimulation was mixed and spread to both muscle and nerve fibers. It was impossible to distinguish the "point" of stimulation in each concrete case.

Typical records of APs of the muscle fibers are given in Fig. 1b, c. In most cases APs appeared as on-responses to the stimulus (Fig. 1b), less often as off-responses. An example of one such potential, using a wide sweep, is shown in Fig. 1c (the stimulus lies outside the frame).

The distribution of the parameters with which we are concerned (MP, amplitude, duration and LP of the AP) is illustrated in Fig. 2. The relatively small recorded values of the amplitude of the APs can be attributed partly to inertia of the loop oscillograph. Control records on the cathode-ray oscilloscope revealed higher values of the amplitude (of the order of 100 mV). The overshoots of the APs recorded on the loop oscillograph also were relatively small for the same reason (5.2 ± 0.4 mV).

The electrophysiological characteristics of the muscle fibers of the supercilio-auricularis muscle obtained in this investigation thus demonstrate that all these fibers belong to the phasic type. The reasons for this conclusion are as follows:

1) The characteristic values of MP and their unimodal and narrow distribution; as a rule tonic fibers have much lower MP values [6];

2) the absence of spontaneous rhythm of PSPs characteristic of tonic fibers;

3) the presence of spike potentials with overshoots in response to stimulation characteristic of phasic fibers. The amplitude of the AP and the size of the overshoots in this object were not very great (on the average 72 and 5.2 mV respectively), but the shape of the potentials was typical for the phasic fibers with spike potentials having a mean duration of 1.5 msec.

The absence of miniature end-plate potentials (in some experiments the potentials were recorded with higher amplification) also shows that the zone of synapses in these fibers was far removed from the point of recording and was localized, a feature that distinguishes phasic fibers from the multiple, scattered innervation of tonic fibers.

The hypothesis that special tonic fibers exist in the supercilio-auricularis muscle was thus not confirmed. The whole of this muscle can evidently be regarded as homogeneous and its tone must be attributable to the asynchronous activity of its phasic fibers, in agreement with the character of its global EMG. The complete absence of this activity under the conditions used was in all probability due to the general anesthesia.

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