EFFECT OF ACOUSTIC AND PHOTIC STIMULI ON ELECTRICAL ACTIVITY OF MUSCLES IN NEWBORN INFANTS

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A high resting level of electrical activity of muscles in newborn infants makes it possible to determine changes in muscle tone from the interference electromyogram. Changes in electrical activity during photic and acoustic stimulation consist of at least two components, the first of which is always tonic, while the second may be either tonic or phasic. If the initial level of electrogenesis in the muscle is high, exteroceptive stimuli reduce it, but if it is low they raise it.

Muscle tone reflects the complex integrated response of the nervous system to a group of impulses arriving from different sources, among which the muscle proprioceptors play the dominant role. However, muscle tone is known to be influenced also by nonspecific stimuli such as sound and light [1-6, 8]. In newborn infants the action of photic stimuli on stretch reflexes has been studied by Vakhrameeva [2]; no other investigations of this problem could be found.

The object of this investigation was to study muscle electrogenesis and the relationship between tonic and motor responses during exposure of newborn infants to acoustic and photic stimuli.

EXPERIMENTAL METHOD

Experiments were carried out on 35 healthy newborn infants aged from 2 h to 7 days. Potentials were recorded by means of a type UBP-4 four-channel ac amplifier with symmetrical inputs and an eight-loop N-102 oscillograph. The noise level of the amplifier with shorted input did not exceed 15 μV. Silver electrodes, 0.4 cm in diameter, with interelectrode distance 1 cm were used, and were fixed along the muscle by means of a cuff. Electromyograms (EMGs) were obtained from the following muscles: biceps and triceps brachii, flexor digitorum communis, quadriceps femoris and spinal muscles. The EMG was compared with the child's movement pattern visually, and in some cases by means of mechanograms.

Weak stimuli, not strong enough to evoke a twitch response followed by vigorous motor activity, were used. Sound with an intensity of 40 dB above the threshold of audibility and with a frequency of 600 Hz, and light from a 60-W lamp situated 1 m above the child's head in an unscreened room were used. The background EMG was recorded, and then again during the action of the stimulus (3-4 sec), and in the afterperiod. During analysis of the EMG, background activity was compared with electrogenesis of the muscle during and after stimulation. Curves with groups of high-amplitude oscillations of between 100 and 250 μV, characteristic of electrical activity during movement, and EMGs with low-amplitude changes, presumably associated with changes in muscle tone, were analyzed separately. The latter were assessed relative to the integral electrical activity over a period of 1 sec, which was obtained by dividing the total of the amplitudes of all oscillations in the chosen segment by the time.

EXPERIMENTAL RESULTS

Electrical activity of muscles of newborn infants at rest amounts to 15-80 μV, a much higher level than in adults [3, 4, 8]. The microstructure of the EMG was characterized by fast (60-120/sec) waves,

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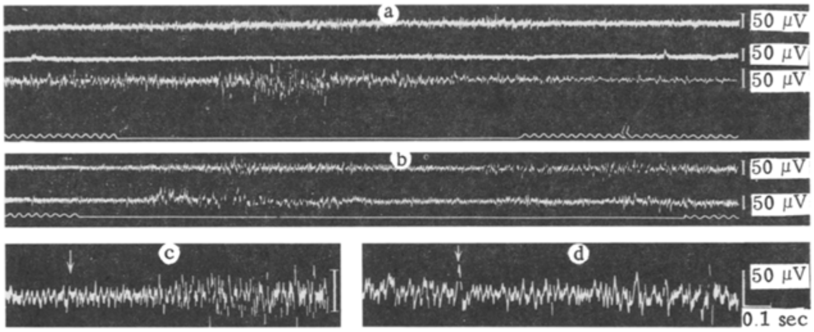

Fig. 1. Changes in electrical activity of muscles during acoustic stimulation. a) EMG of spinal muscles, of quadriceps femoris, and of biceps brachii; b) EMG of biceps brachii and of flexor digitorum communis; c) EMG of biceps brachii, magnified twice, with tonic and phasic components of response. Arrow indicates time of starting stimulation; d) the same, absence of phasic component.

variable in shape and unequal in amplitude. During changes in motor responses, immediate and fine changes in muscle electrical activity took place depending on the character of these responses. Using Yusevich's classification [8], most of the EMGs obtained belonged to the first type. The electrical activity of the resting muscles was distinguished by constancy of all parameters of measurements in the same child in the course of one observation. Comparison of resting potentials in different infants revealed substantial individual differences, suggesting different levels of electrical activity and, perhaps, different levels of tone in newborn infants. The integral electrical activity varied in individual infants from 60 to 930 μV/sec, with a mean value of 570±88 μV/sec (biceps brachii muscle).

During motor activity, the EMG showed groups of high-amplitude oscillations, with an amplitude of 2-4 times greater than the resting level, namely, 250 μV. The duration of these groups was 0.5-1.5 sec. Sometimes groups of this type also appeared without visible mechanical displacements. Changes of this type were described as a manifestation of phasic activity.

Weak acoustic and photic stimuli produced changes in muscle electrogenesis in 98% of cases, the electrical activity being sometimes decreased compared with the initial level. In most cases changes of tonic type were observed in the muscles of the spine and the quadriceps femoris. In the biceps brachii muscle changes of tonic type were found in 16 of 35 infants, and changes of phasic and tonic type in 19 (Fig. 1a, b). During the action of the stimuli all the EMGs had a definite structure, including at least two components: initially, after a short latent period (0.02-0.05 sec), small changes of electrical activity lasting 0.2-0.8 sec appeared, differing both from the background and the subsequent changes (Fig. 1c). Next followed either high-amplitude changes or tonic changes, although they differed from the first component (Fig. 1d) and persisted for a long time after interruption of stimulation. Tonic and phasic types of responses thus were mutually connected in the macrostructure of the EMG, tonic changes always preceding phasic. This applied to all muscles tested.

EMGs without phasic components were used to calculate the integral electrical activity. The direction of the response, i.e., an increase or decrease in integral electrical activity, depended on the initial level: calculation of the polychoric index of correlation between the integral background activity and direction of the response during stimulation revealed correlation of the second degree of significance ($\rho = -0.19$). The existence of this correlation suggests that calculation of the means cannot reveal significant differences between the background, the response to stimulation, and the aftereffect, and for this reason all EMGs were divided into two groups, depending on the direction of the response. The first group contained EMGs of children whose muscle tone was higher than the background level both during and after stimulation. The second group included EMGs of children whose muscle tone was reduced both during and after stimulation. In 3 of the 16 newborn infants, responses to stimulation and aftereffects were in different directions. The groups contained equal numbers of children. It is clear from Fig. 2 that the increase in level of electrical activity produced by acoustic stimulation occurred in infants with a low initial level, and the decrease in tone in infants with a high initial level of electrical activity.

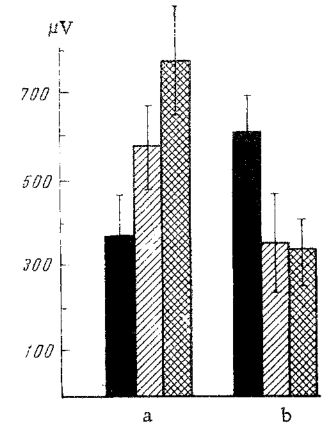

Fig. 2. Relationship between level of activity and direction of response in muscle during acoustic stimulation. a) Group of EMGs with increased integral activity under the influence of stimulation; b) group of EMGs with reduced electrical activity under the influence of stimulation. First column denotes level of integral electrical activity in background, second column the same during stimulation, third column, aftereffect.

During the action of photic stimuli, the responses were more uniform, and there was a tendency for muscle tone to be increased, particularly during the after-period.

The considerable electrical activity of resting muscles in newborn infants may be associated with immaturity of the higher levels of the central nervous system and the absence of inhibitory influences on the reticular formation of the brain stem, regulating γ-motoneuron activity [10, 11]. One result of this is considerable facilitation of reflexes characterizing posture and motor activity, and this means that changes in muscle tone during the action of different stimuli can be determined not only by means of special tests, such as the stretch reflex, or palpation, but also on the basis of analysis of the interference EMG. High sensitivity of the neuromotor apparatus, even to weak, nonspecific stimuli, can be explained both by the special features of regulation of the neuromotor apparatus and also by distinctive features of the neonatal human central nervous system as a whole, and by its tendency to generalized and widely irradiating responses.

Exteroceptive stimulation influences the segmental system of the spinal cord through the brain-stem nuclei and reticular formation, modifying its functional state [7]. Acoustic stimulation can also directly evoke activation of the anterior roots of the spinal cord, the latent period of this effect being 20 msec [9], in agreement with the latent period of tonic changes in the present investigation. Changes in tonic activity, always preceding changes in phasic activity, can tentatively be explained by preparation for movement. Increased electrogenesis may be correlated with recruiting of motor units, and its decrease with relaxation of the muscle from the high degree of tonic contraction preventing phasic activity. This may also explain the relationship between the level of activity and direction of the response during exposure to the stimulus. Some form of optimal level evidently exists for each particular muscle, and is maintained by a system of interaction between α- and γ-motoneurons.

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