STUDY OF THE AUDIOSPINAL EFFECT ON THE H REFLEX

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One method of quantitative evaluation of the functional state of spinal motoneurons is by means of monosynaptic reflexes. Their connection with the cortical motor centers are sufficiently well known and have been recorded by several workers [2, 3, 5, 8, 11]. A detailed study of the effect of acoustic stimulation on H and T responses has demonstrated bimodal changes in reflex responses [3]. However, all these investigations were conducted on normal subjects. Investigation of the audiospinal effect on reflex responses after traumatic injury to the spinal cord is particularly interesting.

The object of the present investigation was to study the effect of acoustic stimulation on monosynaptic H reflexes in patients with various degrees of spinal cord damage and at different segmental levels.

EXPERIMENTAL METHOD

H reflexes were recorded in normal subjects and patients with spinal trauma from the gastrocnemius and soleus muscles by means of a standardized method [9]. Recording electrodes 0.70 cm^2 in area were applied to the belly of the muscles at a distance of 2 cm apart. One stimulating electrode was located in the popliteal fossa, the other above the patella. In all investigations the lower limb was in the same position: The angle between the foot and leg and the angle between the leg and thigh were approximately 90°. The medial popliteal nerve was stimulated and action potentials recorded from the muscles by means of a Medicor (Hungary) myograph. Square pulses 1 msec in duration were used for stimulation. Conditioning stimulation was applied binaurally through earphones. The frequency of the stimulus was 500 Hz and its duration 30 msec. Intervals between the electrical stimulus and conditioning acoustic stimulation varied from 15 to 150 msec. All experiments were carried out under identical conditions in a special chamber. Altogether eight normal subjects and 21 patients with a traumatic lesion of the spinal cord (eight patients with paraparesis and 13 with paraplegia of the lower limbs) were studied.

EXPERIMENTAL RESULTS

The study of the audiospinal effect on the H reflex in normal subjects and patients with spinal trauma was preceded by a study of dependence of changes in H reflex responses on the strength of the stimulating current. Action potentials and curves of dependence of amplitudes of H reflex and M muscular responses on stimulus strength between subthresholds and twice the threshold strength are illustrated in Figs. 1a and 2a (curve 2). The curves obtained with normal subjects were similar to those described previously [4, 10]. Similar curves were obtained for patients with paraparesis of the lower limbs due to trauma predominantly of the lower segments of the spinal cord, and with paraplegia of the lower limbs after trauma to the superior thoracic and cervical segments (Fig. 2a-d, curve 1). It will be clear from Fig. 2 that the character of curves of H and M responses did not differ significantly in normal subjects and in patients with lesions of the spinal cord at different levels. However, a special comparative analysis of curves obtained from patients with spinal cord injury and normal subjects showed that maximal values of H and M responses were higher in the normal subjects than in the patients. This can evidently be explained by the prolonged adynamia of the patients, leading to disturbances of the hemodynamics and of functions of the muscular system [1, 6, 7].

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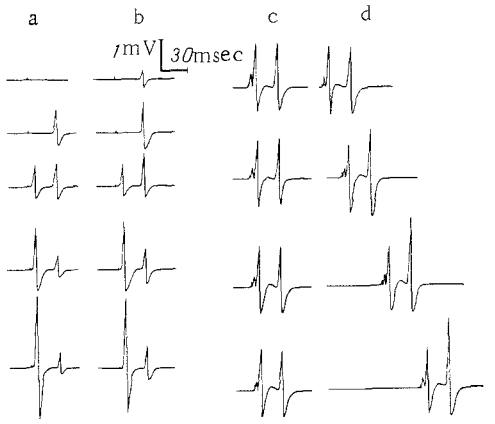

Fig. 1. Effect of an increase in the stimulating current and of changes in the interval between acoustic conditioning and electrical testing stimulation on H reflex responses before (a, c) and after (b, d) short-term acoustic stimulation.

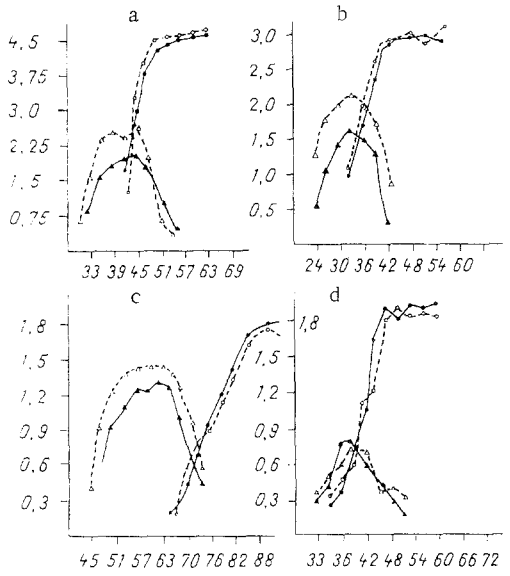

Fig. 2. Dependence of changes in H and M responses on increase in strength of stimulating current with constant 50-msec interval between acoustic (conditioning) and electrical (testing) stimulation in normal subject (a) and in patients with spinal cord trauma with paraparesis (b) and with paraplegia (c, d). Abscissa, strength of electrical stimulus (in V); ordinate, amplitude of action potentials of H and M responses (in mV).

If conditioning acoustic stimulation was applied 50 msec before the testing stimulus the amplitude of the H reflex responses in normal subjects was increased by 30-70% (Fig. 1b, d; Fig. 2a, curve 2). An increase in amplitude to H responses to acoustic stimulation was observed in all patients with paraparesis of the lower limbs following trauma to the lower segment of the spinal cord (Fig. 2b, curve 2). By contrast, in patients with paraplegia of the lower limbs due to trauma to the spinal cord in the upper thoracic or cervical segments, acoustic conditioning stimulation caused an increase in amplitude of the H reflex response only in some of the patients tested. For instance, in seven of 13 patients with trauma to the cervical region of the spinal cord an increase in amplitude of between 30 and 60% was obtained (Fig. 2c, curve 2), whereas in six such patients no increase was obtained in the amplitude of the H reflex response to conditioning acoustic stimulation (Fig. 2d, curve 2). Two hypotheses were put forward to explain this fact: either it could take place as a result of

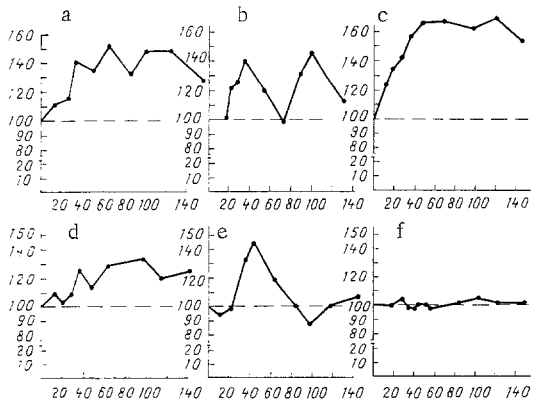

Fig. 3. Dependence of changes in H relfex responses on increase in interval between acoustic conditioning and electrical testing stimuli, with testing current of constant strength, in normal subjects (a) and in patients with spinal cord trauma with paraparesis (b, c) and paraplegia (d, e, f). Abscissa, interval between acoustic (conditioning) and electrical (testing) stimuli (in msec); ordinate, increase in amplitude of H response (in %).

functional blocking or anatomical interruption of continuity of the spinal cord or, as a result of trauma, the velocity of conduction of excitation along the descending tracts of the spinal cord could be reduced due to a tunnel-like effect, causing lengthening of the latent period of the H reflex response, so that it appeared later than expected. To test the second hypothesis special investigations were carried out. The strength of the stimulating current at which H and M responses of equal amplitude were recorded was determined, but under these circumstances intervals between the conditioning acoustic stimulus and the testing stimulus were varied from 15 to 150 msec.

First, normal subjects were tested. In response to the testing stimulus and under the influence of acoustic stimulation the amplitude of the H response was found to be increased after 20 msec. Curves of dependence of the increase in amplitude on increase in the interval between conditioning and testing stimuli in most subjects were found to be biphasic in character (Fig. 3a). The first peak occurred 30-40 msec after the conditioning acoustic stimulus, the second appeared 80-100 msec after the stimulus. These results agree with data obtained by other workers [3]. A similar increase in amplitude of the H responses was found in patients with a traumatic lesion of the spinal cord in the lower segments and in some patients with a traumatic lesion of the spinal cord in the lower segments and in some patients with a lesion of the cervical or upper thoracic segments (Fig. 3b-e). However, in those patients with no increase in amplitude of the H response when the interval between conditioning and testing stimuli of threshold strength was 50 msec, there was likewise no increase over the range of intervals from 15 to 150 msec (Fig. 3f). The bimodality of the increase in amplitude of the H responses was more marked in some patients than in normal subjects (Fig. 3b).

During explanation of the bimodal increase in amplitude of the H responses in normal subjects, it has been suggested [3] that excitation of the auditory analyzer induces excitation of the motor cortex, which spreads to motor centers of the spinal cord along two pathways: pyramidal and reticulospinal. If this explanation is accepted as true, it can be concluded that in patients with spinal cord injury, on whose curve one peak of increase in amplitude of the H response was recorded in the region of 40 msec (Fig. 3e) conductance was maintained evidently only along the pyramidal tract. The absence of an increase in amplitude on the curve of H reflex responses to the conditioning acoustic stimulus (Fig. 3f) is evidence of functional blocking of both pathways and also, perhaps, of anatomical interruption of their continuity.

It can thus be concluded from the data described above that cortical connections with spinal α-motoneurons, which constitute a part of the monosynaptic reflex arcs, are effected by at least two spinal tracts. Furthermore, the technique of the audiospinal effect on monosynaptic H reflexes can be used for diagnostic purposes to determine the existence of conduction of excitation along descending spinal tracts in patients with traumatic lesions of the spinal cord.

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ENERGY HOMEOSTASIS AND NATURAL BIOLOGICAL MODELS

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One of the principal homeostasis control circuits is interaction between energy flows (1, 3]. This interaction takes place in accordance with the principle of reciprocity [5]. It must therefore be postulated that linked functional processes, with discrete energization, can be used as a model with which to study some aspects of homeostasis. It was in fact shown previously [2] that insolation has unequal effects on the duration of two coupled phases of systole, namely isometric contraction (Ic) and ejection (E) which, as we know, have reciprocal energization [4].

It was accordingly decided to compare the dynamics of the duration of these phases of systole during seasonal fluctuations in the energy background (winter, summer), allowing for the possible effect of typological and sex differences in homeostasis.

EXPERIMENTAL METHOD

Tests were carried out on 375 normal persons aged 18-20 years (244 men and 131 women). As was described previously [2], the phases of the cardiac cycle (CC) were determined by recording physiological parameters during a period of 10-12 h in January and in July. After analysis of the data by Student's test they were analyzed for the group of subjects as a whole, and also for separate groups of persons of both sexes with a background duration of CC of 0.65, 0.75, 0.85, 0.95, 1.05, or 1.15 sec.

EXPERIMENTAL RESULTS

The duration of energy-consuming phases of systole was shown to be definitely dependent on seasonal fluctuations in the energy background. However, although Ic and E are linked functional processes, the character of this dependence showed significant differences for each of the phases of systole. For example, in persons of both sexes low and almost equal correlation between values of Ic and CC was observed in summer, but in the winter season this correlation changed in opposite directions in men (a decrease) and in women (an increase). Conversely, high correlation between E and CC was stable only in men, for it increased appreciably in women in the summer season of the year.

Two basic facts can be discerned in the typology of duration of Ic and E (Fig. 2). First, during a change in the background value of CC from 0.65 to 1.15 sec, the trend of E was almost linear, but not that of Ic. Second, different degrees of energy-dependence of the phases of systole compared were found in the subjects of the separate groups. High energy dependence

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