SOME ELECTROPHYSIOLOGICAL DATA ON CONTRACTURE OF THE ANTERIOR ABDOMINAL WALL (DEFENCE MUSCULAIRE).

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Rigidity of the anterior abdominal wall is of purely functional origin. Contracture of the muscles is here of a protective nature and affords a valuable diagnostic sign. It takes place as a visceromotor reflex [4, 7, 8, 10 and others], is of sharply segmentary distribution, and is of very long duration [4, 7]. According to P. P. Goncharov and V. N. Chernigovskii [6, 8], it may develop from stimulation of the interoceptors of a number of viscera. Ya. B. Lavochkin [5], on the other hand, considers that it can arise only from stimulation of the parietal peritoneum.

L. A. Orbeli [7] emphasizes the importance of the sympathetic nervous system in the development of abdominal rigidity. He believes, on the basis of the work of M. P. Brestkin and Ya. V. Lavochkin [1], that involvement of the sympathetic system is a necessary condition of development of rigidity, and that it is responsible for the segmentary character of the contracture, and for absence of fatigue of the affected muscles. The nature of the contractive action of the muscles taking part in guarding is considered to be different from ordinary voluntary contraction of skeletal muscle, and is analogous in general to tonic contraction [1, 2, 4, 6, 7].

In accordance with this view, Pal [9] has proposed the term viscerotonic reflex for this phenomenon, thus distinguishing it from ordinary motor contraction.

Still less is known about the central mechanisms of this phenomenon. These are touched upon in V. N. Chernigovskii's papers [6] and in those of E. N. Zhukov et. al. [3]. Ya. V. Lavochkin confirmed the spinal nature of this reflex.

It thus appears that the phenomenon of protective contracture of the abdominal wall has not been sufficiently studied. In particular, we have not been able to find in the literature any reports on the electrophysiological aspects of this contracture.

EXPERIMENTAL METHODS

The experiments were performed on unanesthetized dogs. Some were done on spinal dogs, in which transsection of the spinal cord had been performed, under inhalational anesthesia, an hour before the experiment, at the boundary between the cervical and thoracic segments. Contracture of the muscles of the abdominal wall was provoked by intraperitoneal injection of 1-3 ml of turpentine into the epigastrium, along the central line.

We studied the electrical activity of the rectus abdominis muscles, by inserting steel needle electrodes into their central parts, at a distance of 2 to 5 cm from each other.

We also, in a series of experiments, observed the action potentials of both rectus muscles. The action potentials were recorded by means of a two-channel cathode oscillograph, type OB-2, with a transmission band from 0.1 to 2000 cps.

In certain experiments we stimulated the sensory nerves (n. peroneus, n. tibialis) by discharges from a neon interruptor.

Parallel with electrophysiological registration we conducted myographic recording of tension in the rectus muscles, by means of a pneumatic cardiograph, which was applied to one of the muscles, and fastened to a holder.

The initial "tonic" state of the rectus muscles of the intact animal is usually characterized by periodic impulses of a relatively low frequency (up to 80 oscillations per second) and amplitude (0.1 mV), clearly connected with respiratory movements (Fig. 1, a, b). The periodic nature of these impulses is due to participation of the abdominal muscles in respiration. With high muscle tonus, constant pulsation is observed, similarly undergoing periodic amplification synchronously with respiration. With a flabby, atonic abdominal wall tonic impulses may not be perceptible with the amplification ordinarily applied in our experiments. We observed, together with the pulsation, using the full transmission band, rhythmic fluctuations of the zero line which increased in amplitude with forced breathing due to displacements of the abdominal wall.

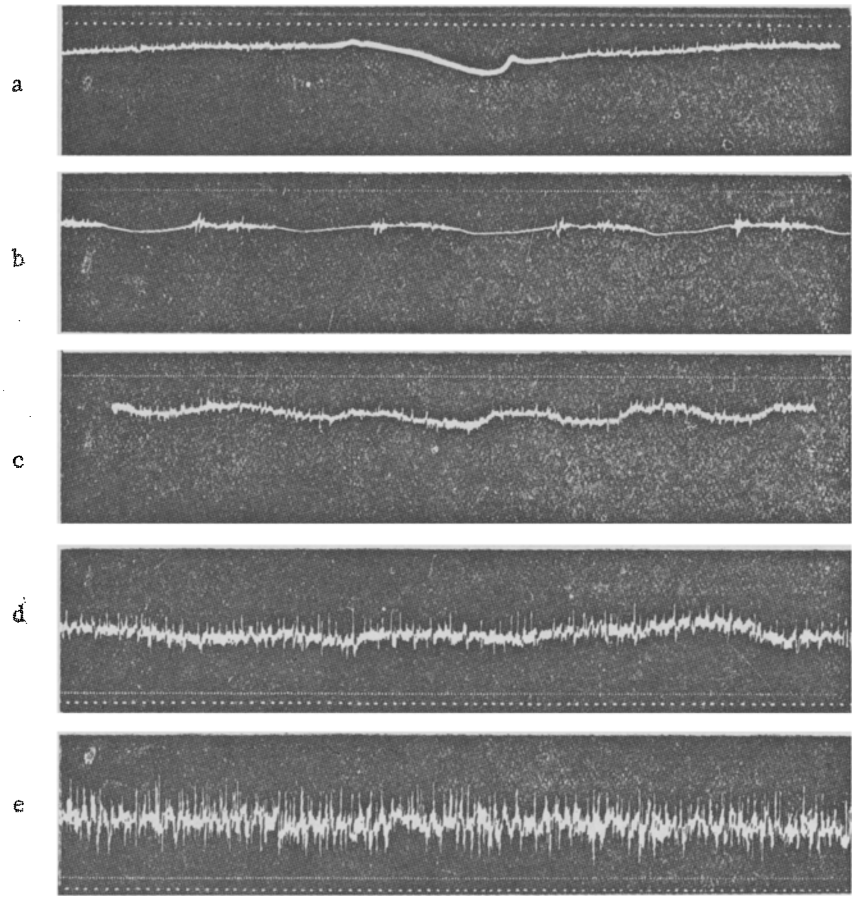

Fig. 1. Electrical activity of dog rectus abdominis muscles. a) initial tonic state; b) idem., during accelerated breathing; c, d, e) development of contracture after introduction of turpentine. Curves: electromyograns and time markers at 0.01 and 0.05 second intervals.

Rhythmic pulsation was not observed in spinal dogs. They exhibit either total absence of action potentials (especially, immediately after section of the spinal cord), or they show continuous waves of low amplitude and frequency.

Introduction of turpentine is followed after 1-2 minutes by a stage of motor excitation of the animal, which struggles and barks. Respiration becomes deeper and more frequent, and vomiting or vomitory movements may supervene. Rhythmic pulsation now appears (if it was initially absent), or becomes intensified, if previously present. The periodicity then becomes smoother and the impulses become continuous (Fig. 1, c,d). In accordance with this, persistent contraction of the muscles supervenes (Fig. 2, a).

a b

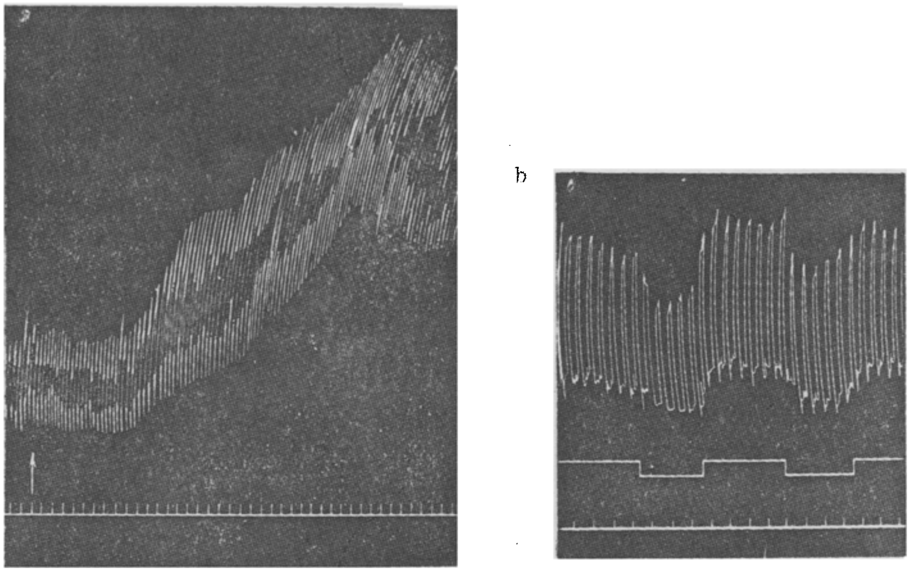

Fig. 2. Myographic registration of contracture of rectus abdominis muscles. a) development of contracture (introduction of turpentine marked by an arrow); b) relaxation of contracture during stimulation (of sensory nerves). Curves: a myogram complicated by respiratory oscillations; marker of time and duration of application of sensory nerve stimulation; time signals (5 sec. intervals).

The excitation phase changes after 3-5 minutes to one of characteristic depression. The animals become immobile and develop a typically cramped attitude. The state coincides with development of the most intense contracture; the abdomen is hard and retracted, and takes no part in breathing. Coincidentally, electrical pulsation reaches maximum as regards frequency (up to 200-300 cps) and amplitude (Fig. 1, e). The amplitude varies irregularly – together with peaks of the order of 0.8-1.5 mv we see small waves of an amplitude of 0.1-0.2 mv. The irregularity and great variety of electrical impulses are noteworthy. Typical regular diphasic and monophasic action potentials are seen only rarely, those observed most often being irregular distorted waves complicated by smaller ones (Fig. 3, a, b). Intense pulsation lasts for 20-30 minutes, and then gradually fades away, being, however, still above normal several hours later. The degree of contracture of the muscles diminishes along with weakening of electrical activity.

Registration of action potentials is the most objective and accurate way of determining the intensity and localization of contracture of the abdominal muscles. Changes which are clearly perceived by electrophysiological methods are often only with difficulty perceived by palpation or myographically. Relaxation of the abdominal wall found in inhalational anesthesia leads to weakening and abolition of the electrical activity of the rectus abdominis muscles.

As a rule, the electrical activity of the left and right recti is symmetrical, but asymmetry is also encountered. Asymmetrical contracture can be produced by introducing the turpentine in such a way that it affects one side only; this is evidence of the existence of delimited receptive zones in the abdominal cavity, stimulation of which causes localized contracture of the muscles.

Of special interest is the marked asymmetry found after preliminary (10-20 days before the experiment) unilateral excision of the abdominal sympathetic ganglia. The intensity of electrical pulsation on the sympathectomized side is much less than in the intact animal (Fig. 3, d). The electrophysiological picture observed confirms the findings of M. P. Brestkin and Ya. V. Lavochkin.

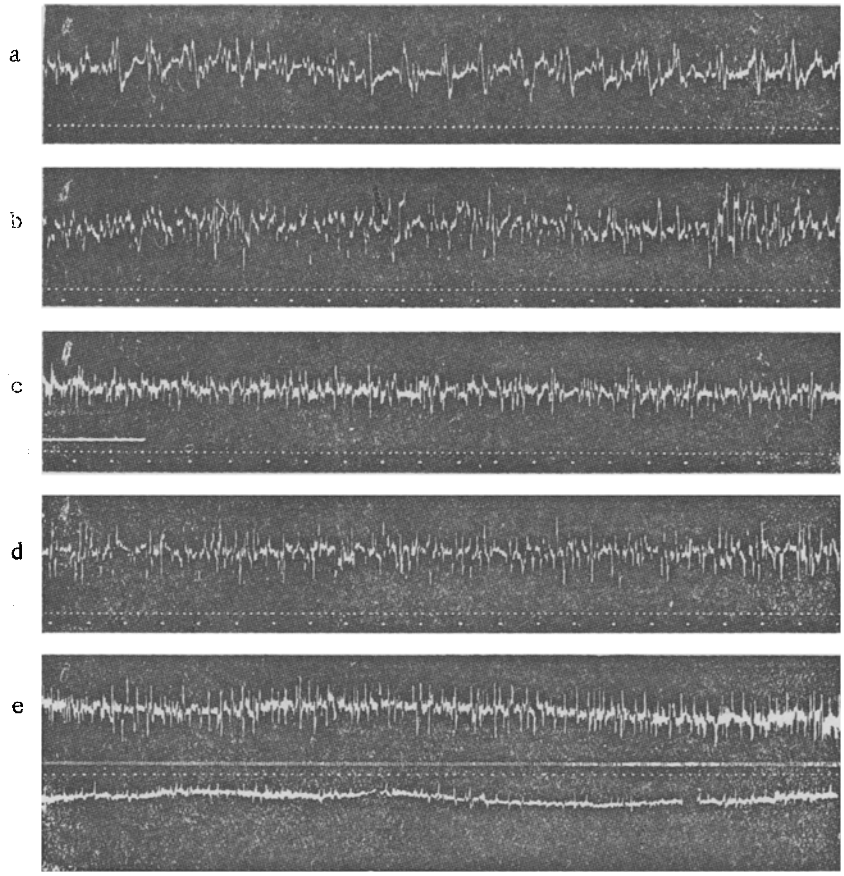

Fig. 3. Electromyograms. a, b) contractures of the rectus abdominis muscles; c) reflex contraction following application of pressure to the abdominal wall; d) electrical reactions of the muscles in pronounced decerebrate rigidity; e) asymmetry of the muscle reaction after unilateral excision of the abdominal sympathetic ganglia. The lower electromyogram refers to the sympathectomized side. Time markers as in Fig. 1.

The contracture and the accompanying electrophysiological effects seen after introduction of turpentine into spinal dogs are very similar, but they develop faster, with a latent period of barely 30-120 seconds. The pulsation is more marked, as is manifested by the large amplitude of the action currents (1.2-1.8 mv.). In such conditions, moderately strong stimulation of the sensory nerves (n. tibialis, n. peroneus) sharply depresses contracture, leading to disappearance of electrical activity and to the relaxation of the abdominal wall during the whole of the period of stimulation.

The discrete nature of the electrical activity found in contracture of the rectus muscles is evidence that it is based on a phasic (tetanic) form of skeletal muscle activity, and not on a stationary process. The contractile activity found in contracture is very similar to that of voluntary movements of the animal, or of reflex contractions of the muscles evoked by pressure applied to the abdominal wall (Fig. 3, c). Notwithstanding the close resemblance of peripheral contractile activity to that found in contracture, however, the reflex applying to the latter possesses a number of significant differences, viz., its very long latent period, of up to several minutes, and its ready inhibition or suppression, as compared with other spinal reflexes.

It should be noted that the contracture, even at its height, does not represent the maximum possible tetanus. Violent voluntary movements of the animal lead to increased tension, with correspondingly heightened pulsation, in the rectus muscles, to values 2-3 times greater than during contracture alone.

Striking features of electrical reaction of rectus muscle in contracture are the irregularity and variation in magnitude of the waves (Fig. 3, a, b). Normal regular action potentials are to be seen, but the prevailing waves are of abnormal shape, and vary in frequency, duration, and amplitude. Larger, more persistent waves alternate with smaller, shorter ones. This irregular, abnormal type of pulsation can, in our opinion, be explained only on the assumption that it is the result of summation of the electrical activity of numerous units, functioning independently of each other, and asynchronously. The asynchronous activity of motor units in contracture is a deciding factor in producing the extreme persistence of contraction of muscle, and in explaining its non-fatiguability in contracture. It is, in this connection, of interest that a very similar electrophysiological picture is encountered in decerebrate rigidity, suggesting that muscle contractions in these two conditions are very closely related in nature (see Fig. 3, b and d).

The fact that contracture of the anterior abdominal muscles, with corresponding electrical activity, can be produced in spinal dogs is evidence that spinal reflex arcs suffice for its development. However, our experiments allow us to suppose that the higher levels of the central nervous system play a certain part in the development of contracture of the rectus muscles, consisting, at least in the early stages, in delaying its onset and in weakening its intensity.

It appears from our results that contracture of the anterior abdominal wall evoked by turpentine injections is due basically to phasic (tetanic) muscle activity, analogous to voluntary contraction and characterized by discrete electrical waves of high frequency and amplitude.

The long duration of the contraction and non-fatiguability of the muscle in contracture are due to asynchronous activity of motor units, the electrophysiological expression of which are the irregular waves of varying frequency, duration, and amplitude.

Registration of electrical activity of muscles is the most objective method of determining the intensity and localization of contractures of the anterior abdominal wall.

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