POTENTIATION OF SPINAL REFLEXES IN RATS AFTER CEREBELLECTOMY

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The appearance of a generator of pathologically enhanced excitation (GPEE) in the nervous system and, in particular, in the spinal cord, under the influence of physiologically active substances was described previously [2]. It has also been suggested that a GPEE appears regularly in various forms of damage to the nervous system. One manifestation of this rule is evidently the development of spinal hyperreflexia after sufficiently massive mechanical injury to the spinal cord [3, 6] or peripheral nerves [4, 7]. Injury to the cerebellum also leads to marked hyperreflexia at the segmental level due to blocking of the inhibitory influences of the cerebellum on supraspinal structures [10]. However, under conditions of chronic cerebellar deprivation extensor rigidity usually gives way after a few days to muscle atony [8]. The question arises: is there a GPEE in the spinal cord under these conditions, and is its appearance or disappearance connected with activity of suprasegmental structures? To answer these questions, we studied reflex responses of the spinal cord under conditions of chronic cerebellar deprivation and showed that supraspinal structures can participate in the regulation of processes of reflex excitability under these conditions.

EXPERIMENTAL METHOD

Experiments were carried out on 26 male albino rats weighing 220-250 g. Under aseptic conditions and hexobarbital anesthesia (5-7 mg/100 g, intraperitoneally), either the whole cerebellum (cerebellectomy, CE) or half of the cerebellum (hemicerebellectomy – HCE) was removed by aspiration. The completeness of CE and HCE was monitored macro- and microscopically after the acute experiment. Animals with an intact cerebellum, either not spinalized or spinalized in the course of the acute experiment, were used as the control group. The animals were used in the acute experiment 3 days after HCE and CE. Rats with marked symptoms of cerebellar insufficiency were studied. Under hexobarbital anesthesia in the above-mentioned dose laminectomy was performed in segments L1-L6, the dorsal and ventral roots in segment L5 were isolated and divided, and their central ends were laid on recording and stimulating electrodes. The animals were given succinylcholine bromide in relaxing doses 3-4 h after laminectomy and were artificially ventilated. Stimulation was applied to the dorsal root (from an ÉSU-2 stimulator) by pulses 0.3 msec in duration and twice the threshold strength for the appearance of dorsal cord potentials. Reflex discharges were recorded from the ventral roots, amplified by means of a UBM amplifier, and photographed from the screen of an S-1-69 oscilloscope. Suprasegmental influences were blocked in the course of the acute experiment by division of the spinal cord at the level T10. Monosynaptic discharges of ventral roots (MDVR) were analyzed – mainly the amplitude, but also the response of MDVR to paired stimulation of the dorsal root of segment of L5 or preliminary stimulation of the dorsal root in segment L4. The results were subjected to statistical analysis.

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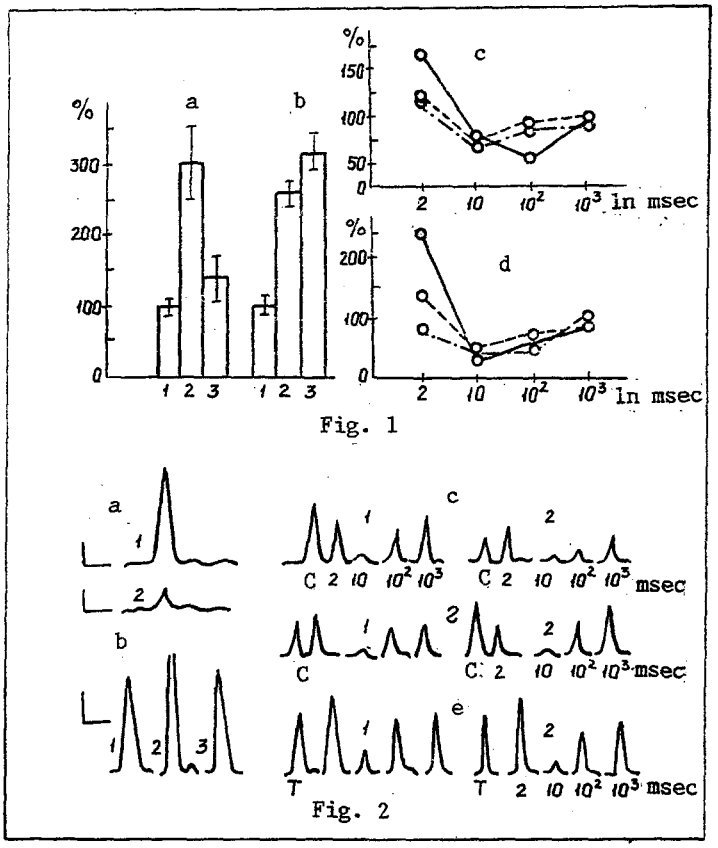

Fig. 1. Mean amplitude of monosynaptic discharges of ventral roots (MDVR) of segment L5 in response to stimulation of dorsal roots in same segment of rats with intact cerebellum and 3 weeks after hemicerebellectomy (HCE) or cerebellectomy (CE): a) amplitude of MDVR in rats with intact cerebellum (1), after HCE on side of operation (2), and on contralateral side (3). In all three groups, animals in acute experiment were not spinalized; b) amplitude of MDVR in rats with intact cerebellum and with spinalization in acute experiment (1), after CE: before (2) and after (3) spinalization; c, d) change in amplitude of MDVR in interval from 2 to 10^3 msec after: c) preliminary stimulation of dorsal root L4; d) preliminary stimulation of dorsal root L5 (paired stimulation). 4 (c, d): continuous line – rats with intact cerebellum (n = 6), broken line – CE before spinalization (n = 7), and line of dots and dashes – CE after spinalization (n = 7). Amplitude of MDVR in response to single stimuli taken as 100%.

Fig. 2. Evoked reflex responses of spinal cord 3 weeks after hemicerebellectomy (HCE) or cerebellectomy (CE): a) HCE, recording on side of HCE (1), on contralateral side (2); b) CE: 1) before, 2) 1 min after, 3) 3 h after division of spinal cord; c) HCE, response to paired stimuli: 1) side of HCE, 2) contralateral side; d) CE, response to paired stimuli: 1) before, 2) after spinalization. 4 (c, d): C) conditioning stimulus, interval 2 msec, triggered from conditioning stimulus, in all other intervals – from testing stimulus; e) CE, response to preliminary stimulation of dorsal root L4: 1) before, 2) after spinalization. T) Response to single stimulus.

EXPERIMENTAL RESULTS

The amplitude of MDVR on the side of HCE 3 weeks after the operation was 306 ± 50% compared with the corresponding parameter in nonspinalized animals, with an intact cerebellum ($n = 6$, $p < 0.05$, Figs. 1 and 2). On the side contralateral to HCE, it was increased to 148 ± 32% ($n = 6$, $p > 0.05$). In response to paired stimulation changes in MDVR appeared on the side of HCE, characteristic of increased motoneuronal excitability – a decrease in the intensity of temporal summation (interval 2 msec). Meanwhile after HCE the scatter of the amplitude of MDVR was quite high. More stable results were obtained after CE. The amplitude of MDVR 3 weeks after this operation was significantly higher than the corresponding parameter in animals with an intact cerebellum (261 ± 13%, $n = 8$, $p < 0.05$). After division of the spinal cord the amplitude of the amplified MDVR not only was not reduced but, on the contrary, it was increased somewhat to 315 ± 26%. Such a small amplification of MDVR under the conditions of acute spinalization has also been observed in animals with an intact cerebellum [3]. No significant changes were present in the response of MDVR to paired stimulation of the dorsal root in animals with CE before and after spinalization. There were no significant changes in the response of MDVR to preliminary dorsal root stimulation in segment L4 in animals with CE before or after spinalization. Meanwhile, tests with paired stimulation of the dorsal root, and with preliminary stimulation of the neighboring dorsal root additionally, together with increased amplitude of MDVR are evidence of increased excitability of the motoneuron pool investigated under conditions of CE. To begin with there was a decrease in the intensity of temporal and spatial summation of MDVR. To some degree reduction of the intensity of presynaptic inhibition of MDVR under CE conditions can also be mentioned.

Two main conclusions can thus be drawn from the results of this investigation. First, a focus of enhanced excitability in the spinal cord is preserved under conditions of not only acute, but also chronic cerebellar deprivation [10]. Second, suprasegmental influences associated with chronic cerebellar deprivation have virtually no part to play in the creation of a focus of enhanced excitability in the motor nuclei of the spinal cord. It must therefore be noted that vestibulospinal influences in animals with chronic cerebellar deprivation differ only a little from those in animals with an intact cerebellum [5].

The character of the spinal changes creating a GPEE in the spinal cord after cerebellar ablation is not yet clear. Provisionally it may be "disuse" hypersensitivity [9], associated with weakening of excitability of gamma-motoneurons and reduction, correspondingly, of the afferent inflow along group Ia fibers to alpha-motoneurons [10]; this mechanism may also explain the development of atony of the extensor muscles under conditions of chronic cerebellar deprivation [8, 10]. Accumulation of factors of neuropeptide nature, modulating excitability of motoneurons, in the same way as the factors of postural asymmetry [1], in the cerebrospinal fluid after CE likewise cannot be ruled out.

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