DIFFERENCES BETWEEN SOMATO-VISCERAL RESPONSES OF ANESTHETIZED AND UNANESTHETIZED ANIMALS

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Electrical responses (activity of the renal nerve) were recorded during stimulation (single and repetitive) of cutaneous afferent fibers in experiments on anesthetized and unanesthetized cats with an intact central nervous system. The long period of postactivation depression after single stimulation and inhibition of electrical activity after low-frequency stimulation of low-threshold afferent fibers are absent in unanesthetized animals and appear only after administration of general anesthetics.

All theoretical views on the organization of somato-visceral responses in animals with an intact brain have been formulated on the basis of experiments performed on anesthetized cats and rabbits [5, 7, 8]. However, anesthetics are known to substantially modify reflex sympathetic responses and, in particular, to distort responses of the arterial pressure to stimulation of low-threshold afferent fibers [4].

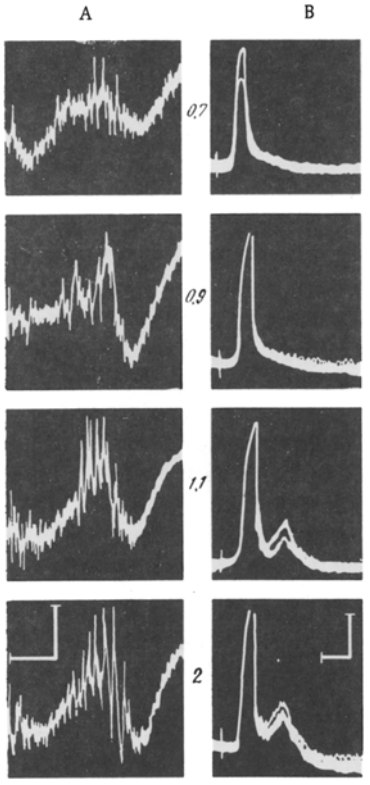

Fig. 1. Potentials recorded in renal nerve (A) and action potentials in afferent fibers of peroneal nerve (B) in response to stimulation of cutaneous branch of peroneal nerve. Numbers on records show amplitude of stimulation (in V), stimulus duration 0.1 msec. B: all curves formed by superposition of 10 sweeps of the beam. Calibration: A) 50 μV, 50 msec; B) 100 μV, 2 msec. Length of peroneal nerve between stimulating and recording electrodes 62 mm.

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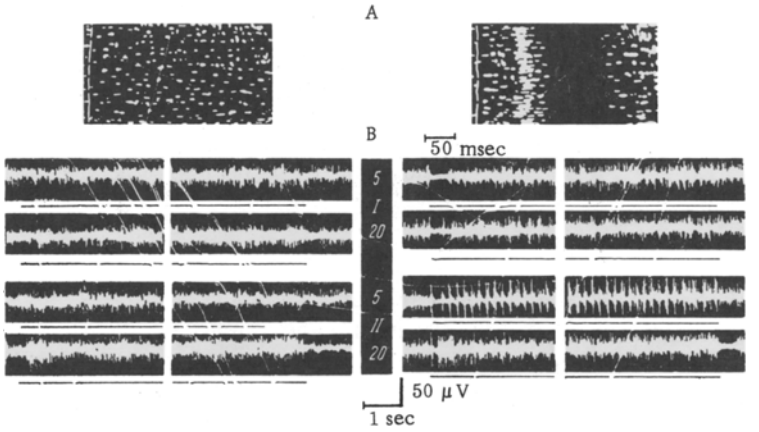

Fig. 2. Potentials recorded in renal nerve in response to single (A) and repetitive (B) stimulation of cutaneous branch of peroneal nerve in unanesthetized cat (on left) and after intravenous injection of urethane and chloralose in anesthetic doses (on right): A) reflex potentials recorded by the "coherent accumulation" method [2] in response to 30 repeated stimulations of the afferent nerve. B: I) stimulation at intensity excited low-threshold group A afferent fibers; II) stimulation at intensity exciting all group A afferent fibers; 5, 20) frequency of stimulation (pulses/sec). Line beneath records is marker of stimulation (15 sec).

It is important to know to what degree results obtained in experiments on anesthetized animals reflect true physiological processes and to what extent they are artefacts due to the use of anesthetic agents. An investigation was therefore carried out to study somato-sympathetic responses in unanesthetized and anesthetized cats with an intact brain.

EXPERIMENTAL METHOD

Experiments (32) were carried out on unanesthetized (ether anesthesia was used for the operative preparation and anesthetized (chloralose 40 mg/kg and urethane 600 mg/kg, intravenously) animals. Electrical activity was recorded in one branch of the left renal nerve (UBPI-01 amplifier, cathode-ray oscilloscope) in response to stimulation of a cutaneous branch of the ipsilateral peroneal nerve (0.4-5 V, 0.1-1 msec, 0.5-50 pulses/sec), and the arterial pressure was recorded at the same time. After the end of the preliminary operation, muscle relaxants were injected and artificial respiration applied. The experiment began 1.5-2 h after the end of the operation.

EXPERIMENTAL RESULTS

Experiments on Anesthetized Animals. In response to single stimulation of the afferent nerve, a reflex discharge which could consist of two components was observed in the renal nerve. In response to stimulation of threshold intensity the reflex discharge appeared after a latent period of 83 ± 12 msec and was accompanied by a long positive potential (up to 300 msec in duration) and followed by a period of depression of electrical activity for 100-700 msec. With an increase in the intensity of stimulation sometimes a second component of the electrical response appeared after a shorter latent period (35 ± 4 msec), and the duration of postexcitation depression increased with an increase in the intensity of stimulation.

The question of which group of afferent fibers it is whose excitation associated with the genesis of these two components of the electrical discharge is of great interest. To shed light on it, simultaneously with the response in the renal nerve, the action potential of the afferent fibers of the peroneal nerve was recorded in a segment 50-60 mm proximally to the point of stimulation. The late component of the electrical response (of very low amplitude) in some experiments (in 3 of 11 cases described in this series) was observed during stimulation of A_β fibers (conduction velocity 45-65/sec). An increase in the intensity of stimulation led to a marked increase in amplitude of the late component of the reflex response, to the ap-

pearance of an A_γ wave in the recording made from the afferent fibers (Fig. 1), and, in two experiments, of a short-latency component of the reflex response. A further increase in the strength of stimulation only slightly increased the amplitude of both components of the electrical discharge recorded in the renal nerve.

During stimulation of afferent fibers at 5-50/sec changes in the activity of the renal nerve depended principally on the intensity of stimulation. In the case of stimulation of threshold intensity, evoking only the long-latency component of the electrical discharge, at a frequency of 5/sec there was an initial period of depression of electrical activity for 0.5-6 sec immediately after the reflex potential, from which recovery gradually took place and whose frequency was close to the initial level. An increase in the intensity of stimulation (stimulation of group A_γ and A_Δ afferent fibers) evoked the appearance of a reflex potential in response to each stimulus (Fig. 2). As a rule stimulation of the afferent fibers at threshold intensity led to depressor responses of the arterial pressure reaching 50-60 mm Hg, while subthreshold stimulation gave a weak pressor response.

These patterns of changes in activity in the renal nerve in response to stimulation at different intensities were also observed if the frequency of stimulation was 10-50/sec. After the beginning of stimulation (of subthreshold intensity) reflex discharges followed the rhythm of stimulation only for the first 2-4 sec, after which electrical activity (frequency of higher amplitude than normal) was not visually connected with the rhythm of stimulation. Similar changes in activity in the renal nerve were observed in response to activation of the descending columns of the spinal cord [1].

Experiments on Unanesthetized Animals. A single stimulus applied to cutaneous afferent fibers evoked not evoke a response in the renal nerve in every experiment. In those cases when a reflex response could be recorded, electrical discharges did not occur to every stimulus. The response to a single stimulus arose if its intensity was sufficient to excite all group A afferent fibers. The reflex potential, just as in anesthetized animals, could consist of two components with analogous latent periods. However, the period of postexcitation depression was observed in the unanesthetized animals only during the positive potential observed after the discharge. In every case in which single stimulation evoked no reflex response, intraveneous injection of chloralose and urethane in anesthetic doses led to its appearance (Fig. 2).

During repetitive stimulation of stimulus intensity sufficient to activate only the low-threshold afferent fibers, depression of electrical activity was not observed in any of the experiments. Stimulation at 1-5/sec evoked no changes in electrical activity of the renal nerve, whereas stimulation at 10-50/sec always led to an increase in the amplitude and frequency of the responses. However, after administration of the anesthetics, stimulation of the afferent fibers evoked changes in the activity of the renal nerve characteristic of those observed in anesthetized animals.

Stimulation of the afferent nerve at an intensity evoking activation of all group A afferent fibers and at a frequency of more than 1/sec always led to increased electrical activity. During stimulation at 5-10/sec (by contrast with the responses obtained in anesthetized animals), the character of the electrical responses was not visually connected with the frequency of stimulation. After administration of the anesthetics a clear connection was observed between stimulus and reflex response.

The absence of a visual connection between the frequency of stimulation and the appearance of reflex responses was evidently due to the relatively short period of postexcitation depression, which corresponds in duration in the unanesthetized animals to the positive potential reflecting after hyperpolarization of the ganglionic neurons, spreading electrotonically in their axons [3]. As these experiments showed, administration of anesthetics considerably prolonged the period of postexcitation depression after single stimuli. According to one hypothesis [9], the long period of postexcitation depression is due to presynaptic inhibition of primary afferent terminals. If this is accepted, administration of urethane and chloralose must strengthen the presynaptic inhibition. However, whereas chloralose does not give this effect, urethane, by contrast, weakens presynaptic inhibition [6]. The question of the nature of the long period of postexcitation depression in anesthetized animals thus requires further investigation.

It can be concluded from the results of these investigations that the long period of postexcitation depression after single stimuli and inhibition of electrical activity in the renal nerve during repetitive stimulation of low-threshold afferent fibers are not physiological processes observed under normal conditions, but they arise only after administration of general anesthetics.

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