NOCICEPTIVE RESPONSES TO MECHANICAL STIMULI

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The appearance of nociceptive responses to pricking the cat's skin with needles was shown to depend on the force, the density of distribution of the needles, and the rate of pricking. Curves of the strength of stimulation versus effect were analogous to those obtained for chemically evoked nociceptive responses and they consisted of two parts corresponding to interoceptive and nociceptive reflexes. With equal loads on the needle the maximal nociceptive responses were obtained with maximal density of distribution of the needles. The greatest nociceptive effect was observed when the pricks were applied at high speed.

A nociceptive response arises to stimuli of any nature if producing tissue destruction. It has been shown experimentally that if certain chemical stimuli are applied to various reflexogenic zones nerve fibers are excited directly. This also leads to the development of a nociceptive effect [1, 2, 4-6].

This paper examines the relationship between the magnitude of the nociceptive response and certain parameters of stimulation. The nociceptive effect was judged from the magnitude of the pressor response.

EXPERIMENTAL METHOD

Cats were anesthetized with ether and urethane. The blood pressure in the carotid artery was recorded by a direct method. The nociceptive mechanical stimuli were needles fixed in transparent plastic discs. Stimulation of the skin by needles is a combination of tactile (contact) and nociceptive (actual pricking) stimulation. Special pins were used as testing tactile stimuli. They consisted of needles with small balls fixed to the sharp ends. The density of distribution of the pins and the load on them were the same as those on the needles. Stimulation was applied to an isolated area of skin of the hind limb supplied by the lateral branch of the cutaneous nerve. The temperature of the isolated skin flap was kept at 37°C by means of a horizontal constant-temperature backing. The area of the reflexogenic zone of the skin to which the stimulus was applied varied from 12 to 80 cm^2 in the different experiments, the density of distribution of the needles per unit area varied from 2 to $30/cm^2$, and the load on the needle varied from 0.1 to 90 g/needle. A device providing vertical movement at speeds of 3, 5, and 10 mm/sec was used to apply the stimuli.

EXPERIMENTAL RESULTS AND DISCUSSION

Stimulation of the skin with needles evoked a reflex increase of blood pressure. The rise of blood pressure with small loads on the needle was small. With an increase in weight of the stimulating needles the blood pressure rose gradually (Fig. 1A). When the load was sufficiently great, the effect of stimulation increased considerably and the blood pressure rose sharply. This effect corresponded to a steep change in direction of the ascending curve of stimulus strength versus reflex (Fig. 1B). With an increase in the density of distribution of the needles per unit area of skin the curves of stimulus strength versus reflex were shifted to the left. Meanwhile the nociceptive threshold of stimulation was reduced (Fig. 1B). With equal loads on the needles a greater nociceptive effect was observed by pricking the skin with a larger number of needles (Fig. 2).

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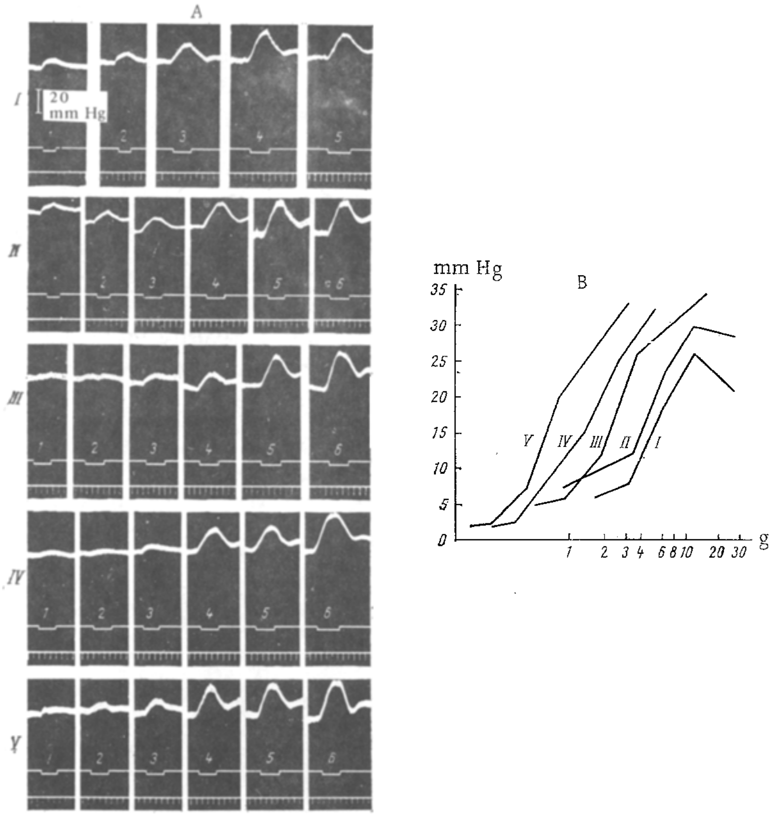

Fig. 1. Reflex responses of blood pressure (A) and curve of magnitude of pressor reflexes in response to stimulation of the skin by pricking versus stimulus strength (B) (one experiment). Density of distribution of needles (number of needles/cm^2): I) 2.1; II) 4.2; III) 8.3; IV) 21.7; V) 38.3. Load (in g) per needle for different densities of distribution of needles. I: 1) 1.6; 2) 3.1; 3) 6.2; 4) 12.5; 5) 25. II: 1) 0.8; 2) 1.6; 3) 3.3; 4) 6.6; 5) 13.1; 6) 26.2. III: 1) 0.5; 2) 0.9; 3) 1.9; 4) 3.8; 5) 7.5; 6) 15. IV: 1) 0.2; 2) 0.3; 3) 0.6; 4) 1.3; 5) 2.6; 6) 5.2. V: 1) 0.1; 2) 0.2; 3) 0.4; 4) 0.8; 5) 1.5; 6) 3. In A from top to bottom: blood pressure, marker of stimulation, time marker (5 sec); in B: ordinate, magnitude of reflexes (in mm Hg); abscissa, load on needle (in g: logarithmic scale).

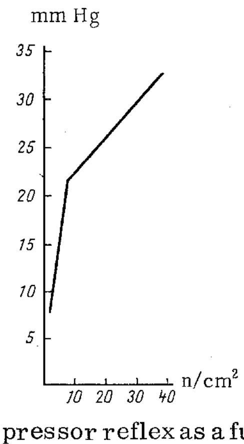

Fig. 2. Magnitude of pressor reflex as a function of density of distribution of needles (1 expt.). Abscissa, number (n) of stimulating needles per cm^2 skin; ordinate, magnitude of reflexes (in mm Hg). Load of needle constant (3 g).

In some experiments small loads on the needles accompanied by pricking of the skin and stimulation with the pins evoked a depressor reflex which changed into pressor as the weight of the stimulating needles was increased.

Maximal pressor reflexes were observed during pricking at the fastest speed.

Since the character of the stimulus strength–effect curve is similar for the action of strong mechanical and chemical stimuli on the skin, in both cases nerve fibers which are the afferent source for the formation of the nociceptive response were evidently excited directly.

The appearance of depressor reflexes in some of the experiments in response to stimulation of the skin by blunt pins and pricking with needles with a small load could be evidence that mainly fibers of the $A\delta$ group were excited. With an increase in the load on the needle a steadily increasing number of C fibers evidently became involved in the excitation, leading to the appearance of considerable pressor references [5, 9, 10].

Once a certain limit of the load on the needle had been reached the decisive factor in the appearance of a pressor response was the density of distribution of the needles. With the same load on the needle a greater nociceptive effect was obtained with the highest density of distribution of the needles. More nerve fibers became involved in the formation of the afferent discharge as a result of their direct stimulation by the needles. Disturbance of the integrity of the tissue also causes substances with nociceptive activity – histamine, intracellular potassium, acetylcholine, kinins [3, 7, 8, 11] – to leave the cells. These, in turn, excite nervous structures participating in the formation of the nociceptive response.

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