

ADAPTATION OF INTEROCEPTORS

COMMUNICATION II. RESTORATION OF THE FUNCTIONAL PROPERTIES OF THE INTEROCEPTORS OF THE URINARY BLADDER AFTER THE REMOVAL OF A LONG-ACTING STIMULUS

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In a previous communication [3] it was shown that certain changes take place in the afferent impulsion in the pelvic nerve in response to prolonged distension of the urinary bladder, i.e., to prolonged stimulation of its interoceptors. Distension of the urinary bladder with fluid elicits an increase in the intensity of the impulses which goes parallel with the increase in intravesical pressure. After reaching a definite level (170–220 mm H₂O), the intravesical pressure was maintained at this level for a long time. The impulsion gradually became weaker; at first its amplitude decreased, then its rate became slower. Finally the impulses ceased although, an expression of the complete adaption of the interoceptors. The adaptation time of the interoceptors was 20–60 minutes.

The aim of the present communication was to demonstrate the process of emergence of the interoceptors of the urinary bladder from the condition of adaptation and the restoration of their original properties after the removal of a long-acting stimulus — a high intravesical pressure.

EXPERIMENTAL METHOD

Experiments were carried out on decerebrated cats or on cats under intravenous urethane anesthesia. After the abdomen had been opened, two cannulae were introduced into the wall of the urinary bladder. Through one of these warm physiological saline was introduced into the bladder under a definite pressure. The other cannula was connected to a water manometer in order to record the intravesical pressure on a kymograph. So that the intravesical pressure could be maintained at a high level, the urethra was ligated. After adaptation of the receptors had been produced, the bladder was emptied artificially through the first cannula. Impulses were taken by means of silver electrodes from the peripheral segment of the pelvic nerve. The animal was placed in a screened chamber. Registration of the electric potentials was carried out by means of a double cathode-ray oscillograph with an amplifier.

EXPERIMENTAL RESULTS

After adaptation of the interoceptors had been produced, as shown by the disappearance of impulsion in the peripheral segment of the pelvic nerve (Figs. 1 and 2, a), the filling of the bladder was discontinued and artificial emptying was started. The intravesical pressure fell accordingly. The fall in the intravesical pressure did not itself cause a flow of impulses (Figs. 1 and 2, c), but the slightest rise in pressure after it had fallen immediately caused impulses to appear in the nerve (Figs. 1 and 2, b). The greater this rise in pressure, the more intensive the series of impulses which it caused.

After completely emptying the bladder, we again introduced fluid into it. The filling took place either immediately after emptying or after a short interval had elapsed, the length of which varied in the different experiments. The duration of the interval varied from $\frac{1}{2}$ to 29 minutes.

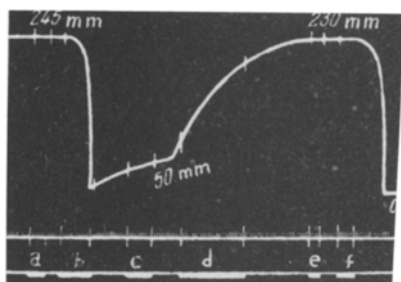


Fig. 1. Registration of the intravesical pressure at the time of its fall and during filling of the urinary bladder a second time. Significance of the curves (from above down): record of the intravesical pressure, time marker (1 second), marker of the moment of picking up impulses.

In all cases impulses appeared in the pelvic nerve in response to refilling of the bladder. The character of the impulsation did not differ from that in the first cycle: it also was intensified parallel with the increase in the intravesical pressure, and it then gradually died away, i.e., adaptation of the receptors developed once more (Figs. 1 and 2, d, e, f.). However, the time of appearance of adaptation in the second cycle depended on the interval of time which had elapsed between the emptying of the bladder and the refilling. The following findings will serve as an example. In the first cycle adaptation of the interoceptors was attained in 54 minutes. In the second cycle, after an interval of 7 minutes, adaptation took place in 22 minutes. After an interval of half a minute, adaptation took place in $1\frac{1}{2}$ minutes. The shorter the time available to the adapted receptors for recovery, the sooner did they become adapted in response to repeated and prolonged stimulation. Experiments showed that when the interval between the cycles was 18-20 minutes, the time of adaptation to repeated, prolonged stimulation of the interoceptors of the urinary bladder equaled the time of adaptation in the first cycle. In these experiments, therefore, 18-20 minutes represented the interval of time required by the receptors, emerging from their state of adaptation, to regain their original physiological condition.

The results obtained demonstrated that when studying adaptation of receptors it is essential to take into consideration not only their ability to restore the flow of impulses after cessation of prolonged stimulation in response to a new stimulus, but also their ability to maintain this flow of impulses for a long time, i.e., to regain their original rate of adaptation.

Whereas the ability to restore the flow of impulses in response to a new stimulus appears immediately after cessation of prolonged stimulation, the ability to maintain this flow of impulses for a long time, and to restore the original rate of adaptation appears significantly more slowly.

The rapid recovery of the ability to give a flow of impulses in response to a new stimulus after the removal of a long-acting stimulus cannot be used as the only criterion of complete recovery of the reactive properties of the receptors. In order to be able to judge the rate of restoration of these properties of the receptors it is

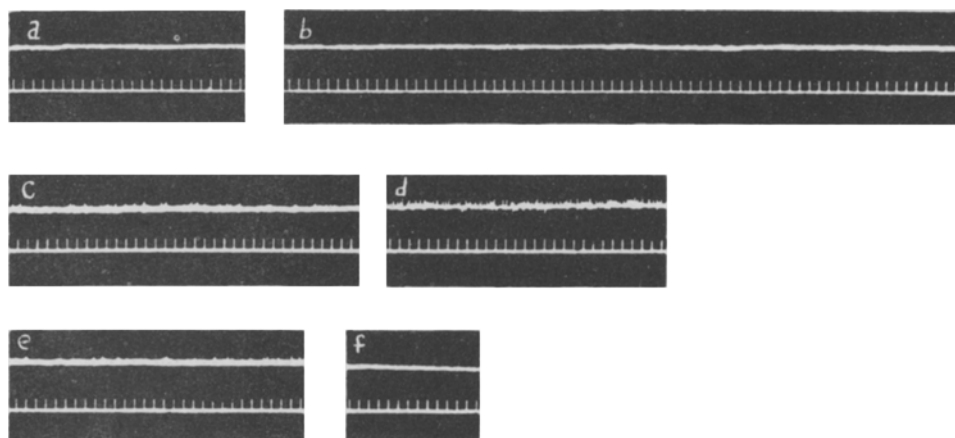


Fig. 2. Registration of impulses from the peripheral segment of the pelvic nerve at the moment of attainment of adaptation of the receptors a), during a fall in the intravesical pressure b), during a slight rise in the pressure c) and during refilling of the urinary bladder (d, e, f). Significance of the curves (from above down): impulses in the peripheral segment of the pelvic nerve, time marker (0.05 second).

necessary to take into consideration the time after which the original rate of adaptation of the receptors is restored.

The findings described in this paper are in agreement with the results obtained by many workers [6, 7, 8, 9] who have studied the adaptation of the pressure receptors of the skin and of the proprioceptors. The researches of these authors showed that adaptation takes place very rapidly (in one second) after the cessation of stimulation, and that the ability to maintain the flow of impulses at a high level is restored more slowly. These authors do not, however, indicate how long it takes for this power to be restored. In our research we have shown that the ability to maintain for a long time the flow of impulses, or in other words to restore the original rate of adaptation, appears 18-20 minutes after cessation of the stimulation.

This is evidently also the time necessary for restoration of the original physiological state of the receptors of the urinary bladder.

So far as the rate of adaptation is concerned, many authors [4, 5, 6, 7, 8, 9, 10, 11] have indicated that this varies for different receptors. Here we must take into consideration the view that the receptors of each organ have their own specific peculiarities, depending on the function performed by the particular organ [1, 2, 6]. The receptors of the urinary bladder, according to Stella [10], become adapted very slowly. According to Talaat's findings [11], adaptation developed after 20 minutes. In our experiments [3] the time of adaptation varied from 25 to 60 minutes.

Our investigations thus showed that, on the one hand, the interoceptors of the urinary bladder obey the general rules characterizing the process of adaptation in receptors; on the other hand, they have their own characteristic features, and in particular, their time of adaptation, which is influenced by the distinctive features of the function of the urinary bladder. This evidently constitutes one of the forms of adaptation of this organ to the particular conditions of its activity.

SUMMARY

Experiments were conducted on decerebrated cats with the aid of oscillographic methods. Disappearance of impulsion in the pelvic nerve served as criterion of adaptation of the receptors when the latter were stimulated by filling the urinary bladder with physiological saline solution. After evacuation of the fluid from the urinary bladder, the receptors lose their adaptation immediately and begin to respond to the new stimulus. The less the time given to the adapted receptors "to rest" the sooner their adaptation in repeated stimulation. The initial rate of adaptation is restored in 18-20 minutes.

Rapid restoration of the ability to respond by impulsion to repeated stimulation cannot serve as the only criterion of complete restoration of the physiological functions of the receptors. When assessing the restoration rate of the physiological function of the receptors one should take account of the time after which the initial rate of adaptation is restored.

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