REFLEX CHANGES IN ACTIVITY OF THE URETHRAL SPHINCTER DURING ADEQUATE STIMULATION OF RECEPTORS OF THE PUDENDAL NERVES

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UDC 612.467.11: [612.819.94:612.815.2

In experiments on cats anesthetized with urethane the relationship between the myographic activity of the urethral sphincter and adequate stimulation of urethral receptors and the skin of the perineum was studied. With a low level of background activity these forms of stimulation evoked mainly an increase in activity. With a high level of background activity stimulation evoked inhibitory responses. During combined application of both stimuli, inhibitory responses were more common.

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The urethral sphincter is formed from circular striped muscles [1, 10, 11], whose afferent and efferent innervation is effected through the pudendal somatic nerves [8]. These same nerves supply the skin of the perineum and genitalia [6]. Many investigations have now been published in which reflex inhibition of activity of the sphincter was observed during stimulation of receptors of the urinary bladder [4,7, 8]. Furthermore, the investigations of Lagutina [3, 4] and of Garry and coworkers [9] have shown that increased activity of the sphincter is observed at low intravesical pressures, changing to inhibition only if the intensity of stimulation is increased. Meanwhile the relationship between activity of the sphincter and afferent impulses passing along fibers of the pudendal nerves remains unexplained. Only in a few papers [9, 10] are indications to be found that stimulation of the pudendal nerves increases the activity of the urethral sphincter.

In the present investigation an attempt was made to determine the quantitative characteristics of changes in this activity during adequate stimulation of the pudendal nerves.

EXPERIMENTAL METHOD

Experiments were carried out on 25 adult cats anesthetized with urethane (1 g/kg intravenously). After laparotomy and removal of the pubic bone a cannula was tied into the proximal part of the urethra, through which warm physiological saline was passed to stimulate the urethral receptors. The rate of flow was approximately the same in all experiments (1-1.5 ml/sec). Stimulation of the mechanoreceptors of the skin of the perineum and genitalia was carried out by stroking with a rounded rod. The pressure of the liquid in the cannula, the electrical activity of the sphincter muscles, and the integral characteristics of this activity determined by means of a diode integrator with time constant 0.5 sec [5] were recorded simultaneously on a loop oscillograph. On the subsequent records the integral of activity was represented in conventional units: one unit was equivalent to a stimulus of 20 μV, 400 Hz.

EXPERIMENTAL RESULTS

A flow of liquid through the urethra gave rise to varied changes in activity of the muscle of the urethral sphincter, the character of the response changing not only from one experiment to another, but also in the course of the same experiment (Fig. 1).

The results shown in Table 1 illustrate that changes in intensity of the response (an increase in activity followed by a change to inhibitory responses) can be attributed to an increase in the background activity. In fact, if a graph is plotted from the results of all the experiments, to show the mean relationship between the level of activity evoked by stimulation (Φ_S) and the level of the background activity (Φ_O), the

Laboratory of Electrophysiology and Medical Electronics, M. F. Vladimirskii Moscow Regional Clinical Research Institute. (Presented by Academician V. N. Chernigovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 67, No. 3, pp. 9-13, March, 1969. Original article submitted April 15, 1968.

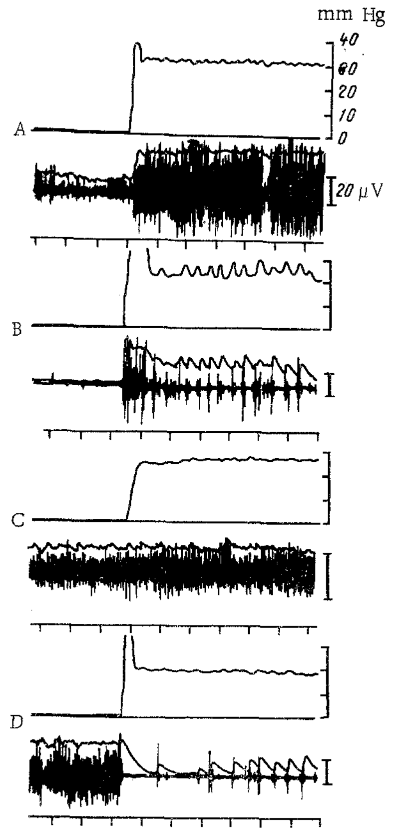

Fig. 1. Types of change of electrical activity of muscles of the urethral sphincter in response to passage of fluid through the urethra: increase (A), increase changing into interrupted activity (B), absence of visible changes (C), decrease (D). On each trace the curves from top to bottom represent: pressure in flow of liquid, integral characteristic of activity, myogram of sphincter, time marker 1 sec.

curve in Fig. 2A is obtained. All the points on this curve lying above the sloping straight line corresponding to the background describe a response of strengthening, while those below the line describe a response of weakening of activity of the sphincter to the same stimulus.

A graph can be plotted from the data on the graph in Fig. 2A to show the relationship between activity of the sphincter and the total afferent flow. The afferent flow evoked by stimulation of the urethral receptors was taken as 1. With a zero background, this stimulation evoked an activity equal to 0.6 unit (Fig. 2A). With an initial activity of 0.6 unit, the addition of this stimulus evoked an activity of 1.7 unit, and so on. In this way points were successively obtained which were then used to plot a graph of the reflex change in activity of the sphincter during stimulation of the pudendal nerve receptors (Fig. 2B).

Stimulation of the mechanoreceptors of the skin of the perineum and genitalia evoked approximately the same responses of the sphincter as passage of fluid through the urethra: an increase of activity, absence of visible changes, and weakening (Table 2). The exception was interrupted activity, which practically never occurred in response to stimulation of the skin. These results show that the character of the response of the sphincter to stimulation of the skin of the perineum and genitalia likewise depended on the level of the initial activity. The graph showing the relationship between the state of the sphincter and the equivalent intensity of stimulation, plotted from the results of experiments with stimulation of the skin (the broken line in Fig. 2B), virtually repeats the graph plotted from the results of experiments with passage of fluid through the urethra.

Stimulation of the mechanoreceptors of the skin of the perineum and genitalia during passage of fluid through the urethra is essentially equivalent to the application of this stimulus in the presence of increased initial activity (Table 3).

In every case in this series of experiments only stimulation of the mechanoreceptors of the skin caused an increase in activity of the sphincter (see the last column in Table 3). However, the same stimulation against the background of activation of the urethral receptors in most cases gave an inhibitory effect. The last case occupies a special position, for it shows that whereas stimulation of the urethra caused inhibition of activity of the sphincter, the addition of stimulation of the skin receptors produced no visible response.

The relationship given above between the level of the afferent flow from receptors of the pudendal nerves and the efferent activity of the urethral sphincter muscles is described by a curve which has a sloping ascending limb, a small plateau, followed by a steep descending limb, terminating in complete inhibition. This curve indicates that the functional state of the sphincter muscles is determined by the number of afferent impulses traveling the corresponding centers from receptors of the somatic reflex arc. This conclusion agrees with Vvedenskii's quantitative principle and it bears some resemblance to the results of Lagutina's experiments [3, 4], in which the relationship between the tone of the sphincter and the number of afferent impulses from the urinary bladder was studied. However, an explanation of the comparative role of afferent impulses from the receptors of the pudendal and pelvic nerves requires further analysis.

The marked change in activity of the sphincter during stimulation of receptors connected with the pudendal nerves suggests that under normal conditions the tone of the sphincter may be maintained by circulation of impulses in a closed reflex ring formed by afferent and efferent fibers. An increase in tone during sudden movements, disappearing after division of the pudendal nerves, may be attributed to an intrinsic reflex of the pudendal nerves.

TABLE 1. Changes in Myographic Activity of the Sphincter during Passage of Fluid through the Urethra

Character of response	No. of cases	Percentage	Background (conventional units)	Level of activity evoked by stimulation (in conventional units)
Increase of activity	28	53.5	0.48	1.5
Increase changing into interrupted activity	13	25	0.72	$2.2 \rightarrow 0.1 \rightleftarrows 2.2$
Absence of visible changes	6	11.5	1.37	1.34
Weakening of activity	5	10	1.94	0.7

TABLE 2. Changes in Myographic Activity of the Sphincter during Stimulation of Mechanoreceptors of the Skin of the Perineum and Genitalia

Character of response	No. of cases	Percentage	Background (conventional units)	Level of activity evoked by stimulation (in conventional units)
Increase of activity	30	73	0.4	1.49
Absence of visible changes	3	7	1.35	1.34
Weakening of activity	8	20	1.87	0.27

TABLE 3. Changes in Myographic Activity of the Sphincter during Summation of Stimulation of Urethral and Cutaneous Receptors

Character of reaction	No. of cases	Percentage	Activity of sphincter (in conventional units)			
			background	stimulation of urethra	stimulation of urethra + stimulation of skin	stimulation of skin
Increase of activity	2	18	0.75	1.65	2.3	1.4
Absence of visible changes	2	18	0.8	1.85	1.9	1.8
Weakening	6	55	0.93	1.95	0.55	1.6
Absence of visible changes against a background in inhibitory action of test stimulus	1	9	1.5	0.2	0.2	2.3

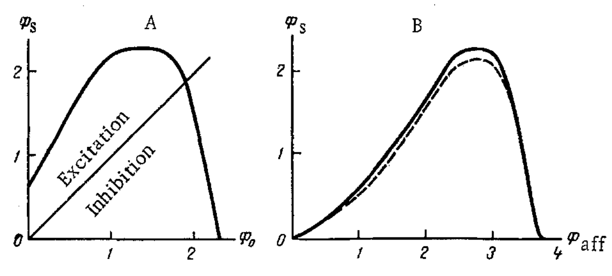

Fig. 2. Relationship between amplitude of response of sphincter to passage of fluid through the urethra and background activity level (A) and total afferent flow (B) during stimulation of urethral receptors (continuous line) and of mechanoreceptors of the skin of the perineum and genitalia (broken line).

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