EFFECT OF RECTAL MECHANORECEPTOR STIMULATION ON THE STRIATED MUSCULATURE

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We have shown [1] that the muscles which carry out the receiver and evacuator functions of the urinary bladder undergo opposite changes: with mild inflation of the bladder, the tonus of the external sphincter of the urethra increases, and the tonus of the abdominal muscles decreases; when the bladder is inflated to a greater degree, the sphincter relaxes, and the abdominal pressure-inducing muscles tense. Change is also observed in the activity of other muscles not immediately associated with the bladder function [2, 3].

How are reflexes on the striated musculature effected under the influence of stimulation of the rectal mechanoreceptors? Urination and defecation have much in common as the bladder and the rectum have the same afferent and efferent innervation.

EXPERIMENTAL METHODS

Experiments were performed on 43 cats under urethan anesthesia (1 g/kg intravenously). The rectal mechanoreceptors were stimulated by means of a rubber balloon, introduced into the rectum and inflated under a specific pressure. The action potentials of the muscles were derived with silver needle electrodes. A two-channel cathode oscillograph with an amplifier having a passband linear within 10-500 cps was used to record them.

EXPERIMENTAL RESULTS

The original electrical activity of the muscles (anal sphincter, oblique abdominal, quadriceps and neck muscles) was recorded first (Fig. 1a and 2a). The lowest threshold of muscular reaction to stimulation of the rectal mechanoreceptors appeared in the anal sphincter. In 50% of the experiments, these threshold reactions consisted in increased bio-electric activity (Fig. 1b), although mild depression of background activity was observed in other experiments in response to the gentlest stimulation (1-10 mm Hg). In both cases, no change was observed in the abdominal muscles with pressures below 15 mm Hg in the rectum (Fig. 1b).

In every case, stronger stimulation of the rectal mechanoreceptors increased the biopotentials of the anal sphincter muscles and inhibited the activity of the abdominal muscles (Fig. 1c). Even stronger stimulation inhibited the activity of anal sphincter and increased that of the abdominal muscles (Fig. 1d, e).

Therefore, as the anal sphincter muscles increase in activity and contract, the abdominal muscles decrease in activity and relax. This reduces the pressure in the abdominal cavity and thus helps increase the holding capacity of the rectum. Contraction of the anal sphincter promotes retention of the rectal contents. Under these conditions, the receiving function of the rectum prevails. As rectal inflation increases, the anal sphincter relaxes and the abdominal muscles contract, causing rectal evacuation.

The reaction threshold of the other muscles rose as their functional and anatomical association with the rectum decreased. Figure 2 shows electrical activity simultaneously recorded in the quadriceps femoris and clavico-trapezoid muscle of the neck. Mild stimulation of the rectal mechanoreceptors caused no change in the activity of these muscles. Moderate stimulation decreased the activity of the quadriceps muscle but did not change that of the neck muscle (Fig. 2b). Stronger stimulation depressed the electrical activity of both muscles (Fig. 2c). The strongest stimulation increased the activity of the quadriceps muscle, although that of the neck muscle was depressed as before (Fig. 2d).

Figure 3 summarizes the experimental results. It is evident that the threshold level and the character of the striated muscle reaction to interoceptive stimulation depends on the degree of receptor stimulation and on the functional connection between the given muscle and the area stimulated.

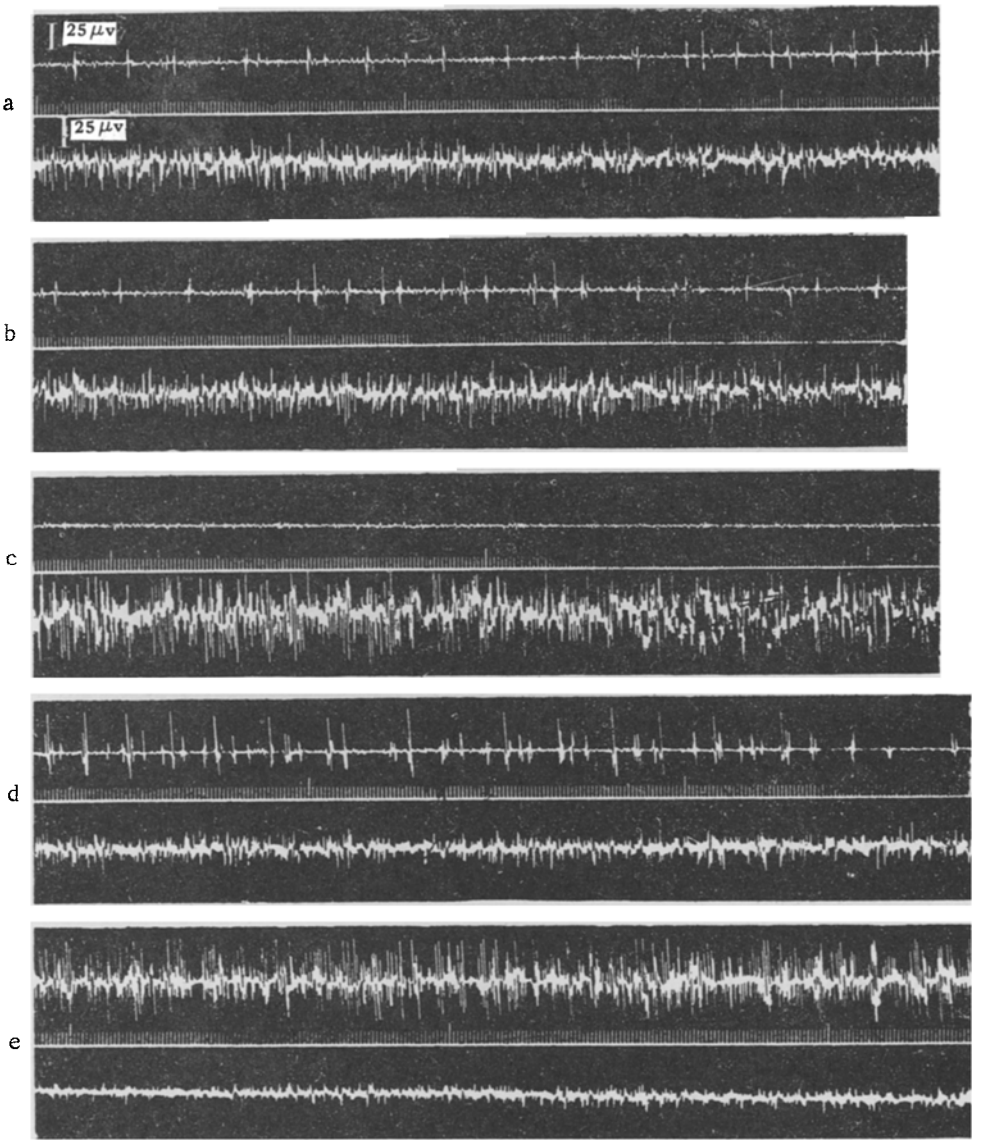

Fig. 1. Change in activity of oblique abdominal muscle and anal sphincter caused by varying stimulation of the rectal mechanoreceptors. a) Original activity of the two muscles with rectum empty; b) change in activity effected by pressure of 15 mm Hg in rectum; c) same with 26 mm Hg; d) same with 56 mm Hg; e) same with 64 mm Hg. Curves (top to bottom) show: activity of oblique abdominal muscle; time in 1 sec marks; activity of anal sphincter.

The reaction of the anal sphincter to increasing stimulation of the rectal mechanoreceptors was primary, consisting initially of relaxation, then, as stimulation increased, contraction, and finally, in response to the strongest stimulation, relaxation again, but more total. The abdominal muscles showed no reaction to the mildest stimulation, but reacted to the moderate (by relaxation) and stronger (by contraction) stimulations. The reactions of the muscles of the posterior extremities were similar, but developed first in response to the medium stimulations (relaxation); extremely strong stimulations caused these muscles to contract. Only the strongest stimulations attained the reflex threshold of the neck muscles; relaxation was observed in response to all effective degrees of stimulation.

The electromyographic changes observed in all the experimental muscles in response to increased pressure in the rectum are generally similar to changes effected by increased pressure in the bladder [1, 2, 3]: the external sphincter of the urethra and the anal sphincter, which are directly associated with the functions of the stimulated

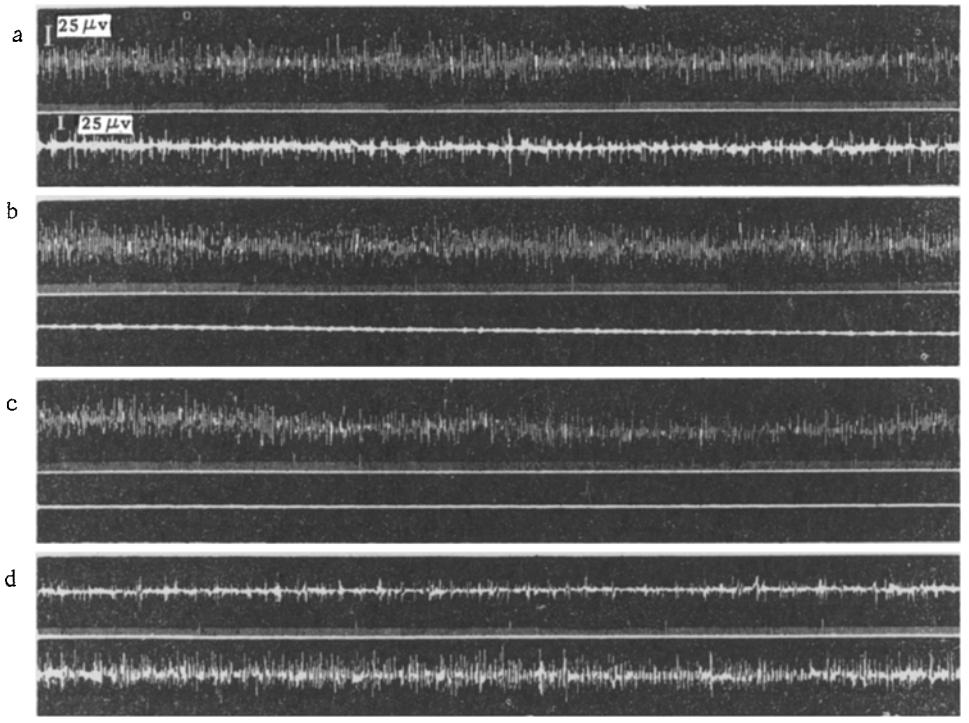

Fig. 2. Change in activity of neck (clavico-trapezoid) and quadriceps muscles caused by varying stimulation of the rectal mechanoreceptors. a) Original activity of muscles with rectum empty; b) change in activity affected by pressure of 28 mm Hg in rectum; c) same with 42 mm Hg; d) same with 110 mm Hg. Curves (top to bottom) show: activity of neck muscle; time in 1 sec marks; activity of quadriceps muscle.

organs, relax with mild stimulation and contract with strong; the activity of the abdominal and tibial muscles is depressed by mild and moderate stimulation, but enhanced by stronger stimulations. This similarity is evidently due to the fact that the elements of the reflex arc are almost identical in the two cases; afferent impulsation from both the bladder and the rectum travels along the pelvic, and hypogastric, nerves, while efferent impulsation travels along the pudendal nerves to the two sphincters and to the skeletal muscles, along the corresponding segmental nerves.

However, the reflexes from the bladder and rectum did differ somewhat: the pressures in the rectum required to produce reactions analogous to those produced by stimulation of the bladder were always considerably higher. This difference is partially explained by the results I obtained in experiments recording afferent impulsation from the rectum or the bladder in branches of the pelvic nerve; these experiments demonstrated that the afferent impulsation generated by various pressures in the bladder and rectum is always much weaker in the latter. This could also explain the higher thresholds of the reflex reactions induced by this weaker impulsation. The same factor made it possible to observe inhibition of anal sphincter activity in response to mild rectal stimulations in half of the experiments, which is much more difficult to detect in the case of the external sphincter of the urethra under conditions of bladder stimulation. Pregnant cats proved an exception, as in these animals, the threshold rectal and bladder stimulations were equal, or that of the rectum was lower.

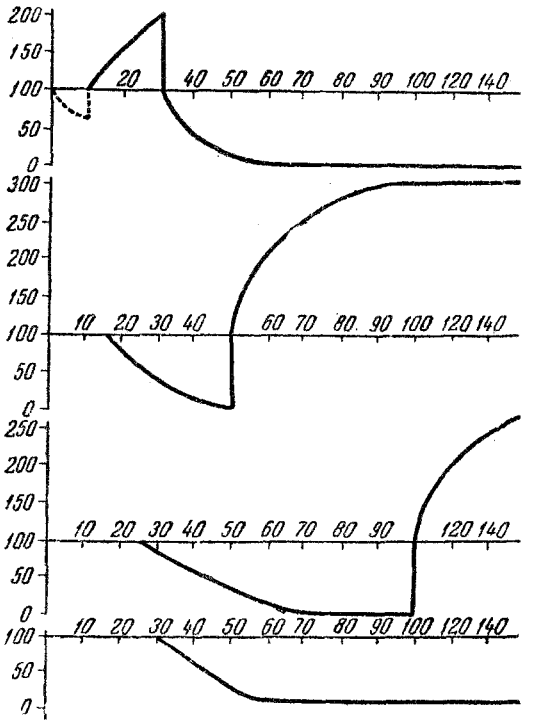

Fig. 3. Relation of reflex changes in activity of different striated muscles to degree of rectal mechanoreceptor stimulation. Abscissa: degree of stimulation (in mm Hg); Ordinate: level of action potentials in (top to bottom) anal sphincter, oblique abdominal muscle, quadriceps, and clavicotrapezoid muscle (in % of original level).

SUMMARY

It was shown in acute experiments on cats (urethan anesthesia) that the threshold value and the character of the striated muscle reaction in response to interoceptive stimulation depends on the intensity of the receptor stimulation and the system of functional connection between the given muscle and the area stimulated.

With a rise of the stimulation intensity of rectal mechanoceptors there primarily occurs a reaction of the anal sphincter, at first (in 50% of experiments) in the form of relaxation, with a somewhat greater stimulation intensity – in the form of contraction, followed by a relaxation, this time more complete. Abdominal muscles begin to react with a somewhat greater stimulation intensity (by relaxation with low stimulation values, and by contraction with higher ones).

Muscles of the lower extremities also react in the same way; however, their relaxation occurs already with medium, and contraction – with higher stimulation values. Finally, with the greatest stimulation intensity reflex threshold is reached in the cervical muscles – they relax in response to all the effective stimulation intensities.

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