Osteovisceral Afferent Interrelations

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The effects of stimulation of intraosseus receptors on visceral afferent reactions were studied in experiments on anesthetized cats. Stimulation of intraosseus receptors decreased the thresholds of evoked potentials recorded in the cerebral cortex in response to stimulation of the heart, stomach, and duodenum. It was concluded that stimulation of intraosseus receptors during osteopathy (*e. g.* increased intraosseus pressure) increases sensitivity of visceral sensory systems and can provoke the development of pain syndromes. It is important that visceral pain in such cases should be considered as a symptom of organ pathology, but not as a manifestation of vertebrovisceral syndrome.

Key Words: *heart; osteoreception; intraorganic control*

A principal peculiarity of the regulation of visceral sensitivity (including nociception) is a multilevel defense system protecting consciousness from interoceptive stimuli in contrast to somatosensory signals with their modality characteristics, which are preemptively addressed to consciousness. Different central assessment of somatic and visceral sensory traffic plays an important evolutionary role. However, the mechanisms of consciousness protection from visceral signals modulate nociception during visceral diseases and determine peculiarities of clinical presentation, *e. g.* development of atypical, painless, or smoothened forms of the pathological processes. These features of visceral sensitivity are determined by peculiar structure of visceral afferent systems, which include the primary sensory elements with intraorganic nervous system, the anatomic and functional peculiarities of precentral visceral interconnections, segmental mechanisms forming visceral afferent traffic, and structural features of its central presentation.

We previously showed that thresholds of visceral sensitivity increase during the acute phase of damage to the heart, stomach, and duodenum, which is manifested by inhibition of evoked afferent reactions and the escape of organs (in particular, the heart) from extraorganic (extracardiac) influences [1,2]. The development of visceral "autonomy" observed at the early stages of pathological proceses is probably based on predominant intraorganic modulation realized via the opioid- and GABAergic mechanisms.

Our aim was to examine the mechanisms of viscerovisceral and viscerosomatic interactions, which play the key role in the modulation of visceral afferent traffic.

MATERIALS AND METHODS

Experiments were carried out on 150 male and female cats. The animals were narcotized with chloralose (50-70 mg/kg intraperitoneally), immobilized with Myo-Relaxin (3-5 mg/kg intramuscularly), and artificially ventilated.

Evoked potentials (EP) were recorded in the cerebral cortex (CC) and medial center of the thalamus (MCT) in response to stimulation of the sinoatrial node, gastric body, duodenal bulb, intraosseus receptors in the head of the humerus and iliac bone with the use of the stereotaxic technique.

The potentials evoked by stimulation of the sinoatrial node were recorded with monopolar insulated stainless steel electrodes (50 μ tip diameter). The electrodes were stereotactically introduced into subcortical structures [5,6]. The location of electrodes was verified on brain sections by anodal coagulation mark.

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Test stimulation was performed with bipolar electrodes (0.1 mm^2 silver contacts at a distance of 0.5 mm). The sinoatrial node was stimulated with single rectangular pulses (0.3 msec, 10-15 mA, 0.3 Hz). The conditioning stimuli were applied to intraosseus receptors in the humeral head and iliac bone. To this end insulated bipolar needle electrodes were used, which excluded electrical stimulation of the periosteal tissues. The location of the electrodes in spongy bone tissue was verified by aspiration. Intraosseus receptors were stimulated with conditioning single and repeated rectangular pulses of various amplitude and duration.

The signals were recorded using a universal Multibasis OTE Biomedica.

The results were processed using Student's *t* test.

RESULTS

Stimulation of the sinoatrial node induced EP in CC and MCT. In these and the following experiments we used paired stimuli, *i. e.* test stimuli were applied to visceral organs, while conditioning pulses were applied to intraosseus receptors. Conditioning stimulation of the humeral head significantly affected the total amplitude of initial phases of EP induced by stimulation of the sinoatrial node. The amplitude of control (without intraosseus stimulation) EP recorded in CC and MCT increased from 147.0±8.4 to 197.0± 8.3 and from 141.0±11.3 to 179±12.3 μV, respectively, at interstimulus intervals of 50-750 msec. Prolonging the interstimulus interval reduced (1000 msec) or even abolished (1500 msec) facilitation of EP formation.

Test stimulation of intraosseus receptors was also significant during stimulation of the sinoatrial node in damaged myocardium. Five minutes after interruption of coronary blood flow, the amplitude of EP in CC and MCT induced by stimulation of the sinoatrial node significantly decreased from 125.0±12.2 to 34.0±3.4 and from 118.0±8.4 to 29.0±11.6 μV, respectively. During this period conditioning stimulation of intraosseus receptors with optimum interstimulus intervals increased EP amplitude in CC and MCT to 128.0±7.6 and 115.0±5.6 μV, respectively (Fig. 1). It is noteworthy that stimulation of intraosseus receptors in the humerus had no effect on the amplitude of EP induced by stimulation of the sinoatrial node. These data suggest that stimulation of intraosseus receptors facilitates the development of afferent reactions in intact and damaged myocardium in accordance with peculiarities of somatosegmental innervation. It is important that facilitation of cardiac afferent reactions was observed only during isolated stimulation of intraosseus receptors, when the spongy substance was pierced with insulated needle (except tip). When uninsulated needle was used, we observed inhibition of test EP, typical effect of stimulation of the periosteum and periosteal tissues, muscles, and skin.

In a special experimental series, test stimulation was applied to the body of the stomach and duodenal bulb during conditioning stimulation of intraosseus humeral receptors. The same regularities were revealed. Specifically, conditioning stimulation of intraosseus receptors significantly facilitated the development of EP induced by simulation of the gastric body or duodenal bulb. When the gastric body was stimulated, the total amplitude of initial EP phases increased to 144.0±19.8 and 184.0±12.4 μV in the absence and presence of conditioning stimulation of intraosseus receptors, respectively. Similarly, stimulation of the duodenal bulb increased the corresponding parameters to 184.0±14.6 and 226.0±10.5 μV. It is noteworthy that variations of interstimulus intervals revealed the same regularities as in experiments with stimulation of the sinoatrial node (Fig. 2). Stimulation of intraosseus receptors was also an essential factor in the study of afferent reactions of organs of the gastroduodenal complex. Uninsulated intraosseus electrodes stimulated receptors of periosteum and periosteal tissues, which completely prevented and even perverted the facilitation of visceral afferent reactions. Conditioning stimulation of intraosseus receptors in the humeral head produced no significant effect on the amplitude of EP induced by stimulation of the gastric body and

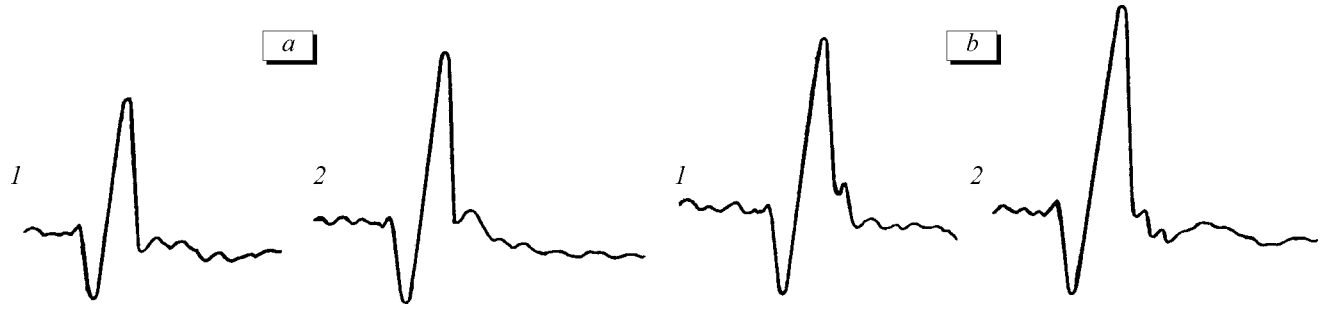

Fig. 1. Evoked potentials recorded in cerebral cortex in response to electrical stimulation of the gastric body (*1*) and duodenal bulb (*2*) in control conditions (*a*) and during stimulation of intraosseus receptors (*b*).

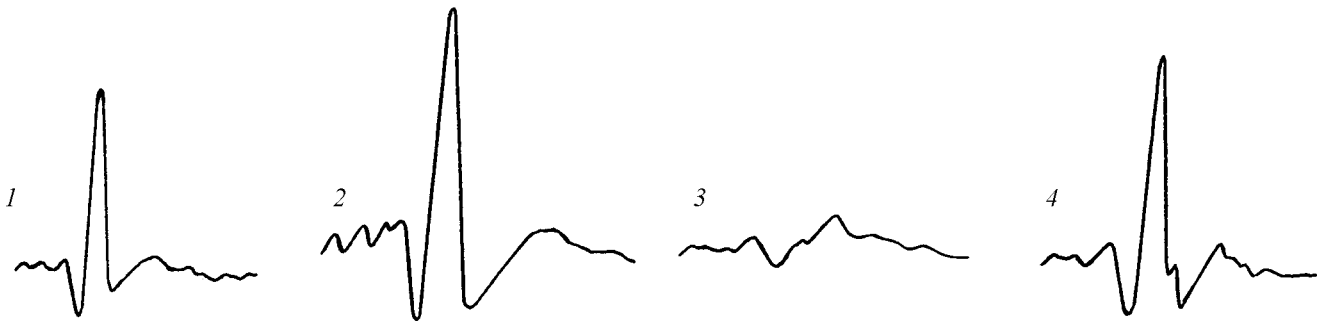

Fig. 2. Evoked potentials recorded in cerebral cortex in response to electrical stimulation of sinoatrial node under the following conditions: *1*) intact myocardium; *2*) intact myocardium+stimulation of intraosseus receptors; *3*) 5-min myocardial ischemia; *4*) myocardial ischemia+ stimulation of intraosseus receptors.

duodenal bulb. In both series, changes in EP amplitude in CC and MCT were co-directed.

The most important phenomenon in our experiments was facilitation of visceral afferent reactions during conditioning stimulation of intraosseus receptors of the spongy bone substance projecting to the common segments in the spinal cord. Published data suggest that the increase in intraosseus pressure and stimulation of intraosseus receptors facilitate somatic afferent reactions and decrease nociceptive thresholds [2-4]. Modulation of somatic and visceral sensitivity after stimulation of intraosseus receptors is probably realized via common segmental mechanisms. Our data agree most closely with the "gate" theory [7], which is now properly substantiated. In particular, afferent systems of the spongy substance consist mainly of slowly conducting fine unmyelinated fibers, which, according to the gate theory, are responsible for presynaptic facilitation of the competitive afferent flows at the level of spinal cord segments. Starting from this postulate, it can be hypothesized that stimulation of intraosseus receptors (for example, caused by increased intraosseus pressure) can decrease the thresholds of afferent reactions in common innervated segments. Specifically, the sensitivity thresholds of some visceral organs can be decreased by this mechanism. In such cases, visceral afferent traffic (normally not perceived) reaches cerebral structures and produces a sensation (*e. g.* pain). It can be hypothesized that pathology of the musculoskeletal system (vertebral column deformity, osteochondrosis, myelocele, arthroses, osteoporosis, *etc*.) can potentiate visceral afferent reactions and trigger various syndromes, which are related to diseases of visceral organs and not manifested during intact state of the locomotor system.

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