ELECTROPHYSIOLOGICAL STUDY OF RECEPTION FROM CERTAIN INTERNAL ORGANS IN MAN

Report I. Impulses from Receptors of the Resected Stomach and Small Intestine

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A natural result of knowledge of interoception, so fruitfully developed in recent years by Soviet and foreign investigators, is the attempt to use the data obtained in this field for clarification of physiological and pathological processes taking place in the human organism. But the quest for such an aim runs up against many difficulties, one of which is the lack of direct data characterizing interoception in man. A large number of investigations devoted to interoception have been in chronic or acute animal experiments, and merely a few isolated researches were carried out in man, in which various reflex actions arising from the mechanoreceptors of the stomach and small intestine were recorded. No direct observations have been made in man on the activity of the receptors (by recording their action potentials), in particular on the chemoreceptors of the internal organs.

In order to clarify the different aspects of venous receptor activity, a method was developed by O. P. Minut-Sorokhtina [4] in the Physiology Department of Khabarovsk Medical Institute, using an isolated vessel-nerve preparation. This preparation, consisting of the isolated vessel with the corresponding afferent nerve, was an excellent model, allowing oscillographic recording of the action current of the afferent nerve for widely varying supraliminal stimulation of the venous receptors. The development of this method gave us the possibility of using various human internal organs, removed during surgery, in the electrophysiological study of reception.*

METHOD

The portion of the organ removed was stirred in Tyrode solution immediately after the operation, and was kept at a lowered temperature until the experiment was begun. Then the organ was perfused with Tyrode solution through one of its arteries. Both the temperature and pressure of the perfusing fluid remained constant throughout the entire experiment. At the start of the experiment an active afferent nerve for recording of action potentials was discovered by using the oscilloscope to monitor such activity. After this, chemical stimuli were administered by perfusion into the vascular system of the organ, or by application on the mucous membrane. We took into account the available data in the literature on the high sensitivity of the receptors of the lesser curvature of the stomach and most often traced out our afferent nerve for recording from the posterior wall of the lesser curvature. In those operations in which the intestine was removed, we made use of a branch of the intestinal nerve. The following chemical substances were used as stimuli: 10% glucose, 1% peptone, 0.1% calcium chloride, and 0.1% caffeine. Sponges moistened with 10% caffeine or 40% alcohol were placed on the mucous membrane. The stimuli were applied several times in the course of the entire experiment. The experiments were performed in a shielded room with the aid of a double beam oscilloscope. Records of the bioelectric currents were photographed on film moving at 25 mm/sec. The writing speed was 800 cycles and the amplification was such that the beam was displaced 4 mm for 25μv, with an interelectrode distance of 2-4 mm.

RESULTS

Twenty-three positive results were obtained in 30 experiments, in which portions of the stomach and small intestine were removed, and in which afferent action potentials were recorded and changes presented under the influence of the chemical substances applied. In seven

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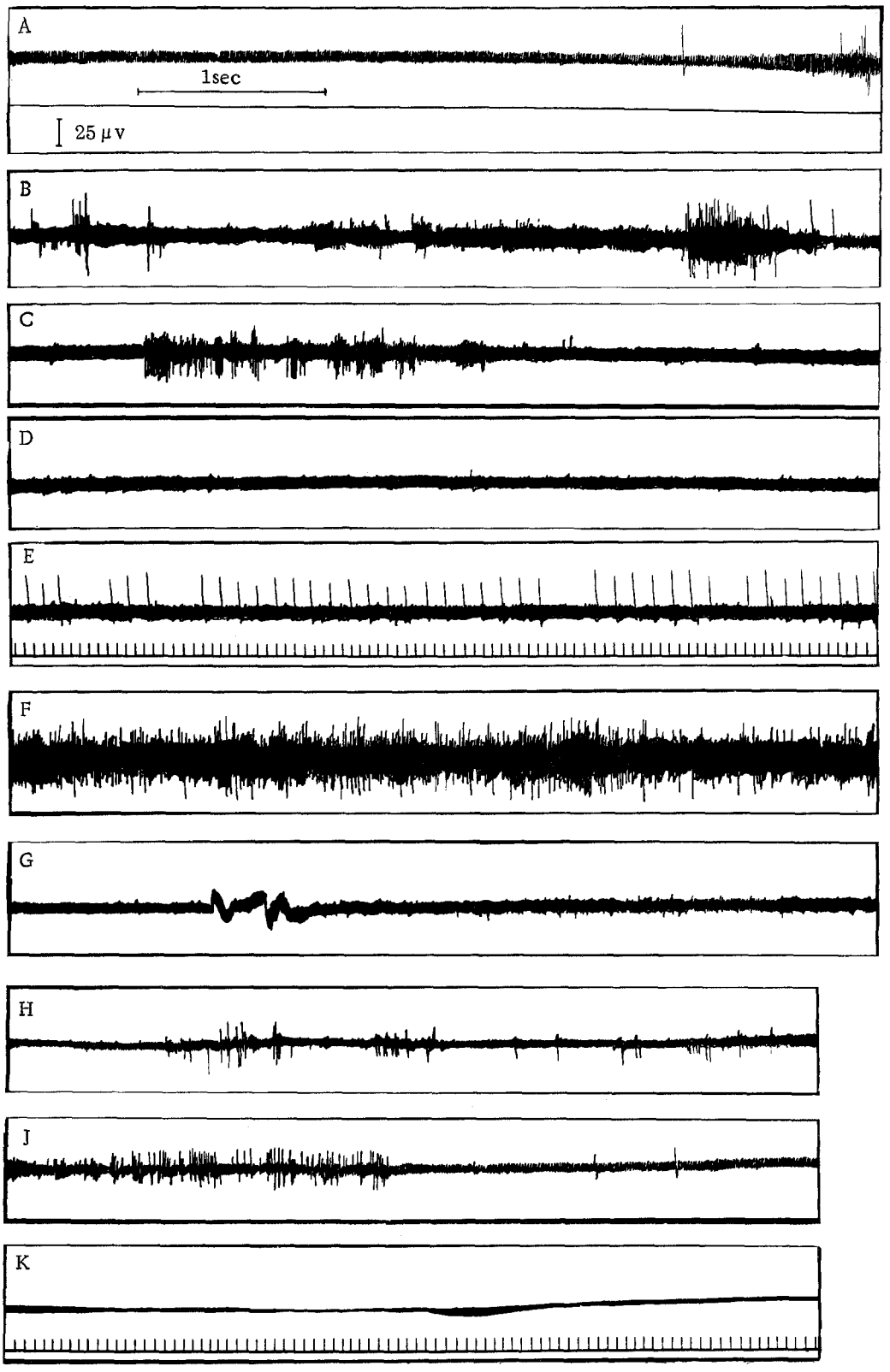

Fig. 1. Change in impulse activity of an afferent nerve of the resected stomach of man during perfusion with glucose, peptone, and caffeine. A) Before perfusion with glucose; B) after 2 minutes of glucose perfusion; C) after 4 minutes of the same; D) after washing out of glucose; E) after 3 minutes of peptone perfusion; F) after 6 minutes of same; G) after washing out of peptone; H) after 1 minute of perfusion with caffeine; J) after 3 minutes of same; K) after caffeine is washed out of perfusing medium.

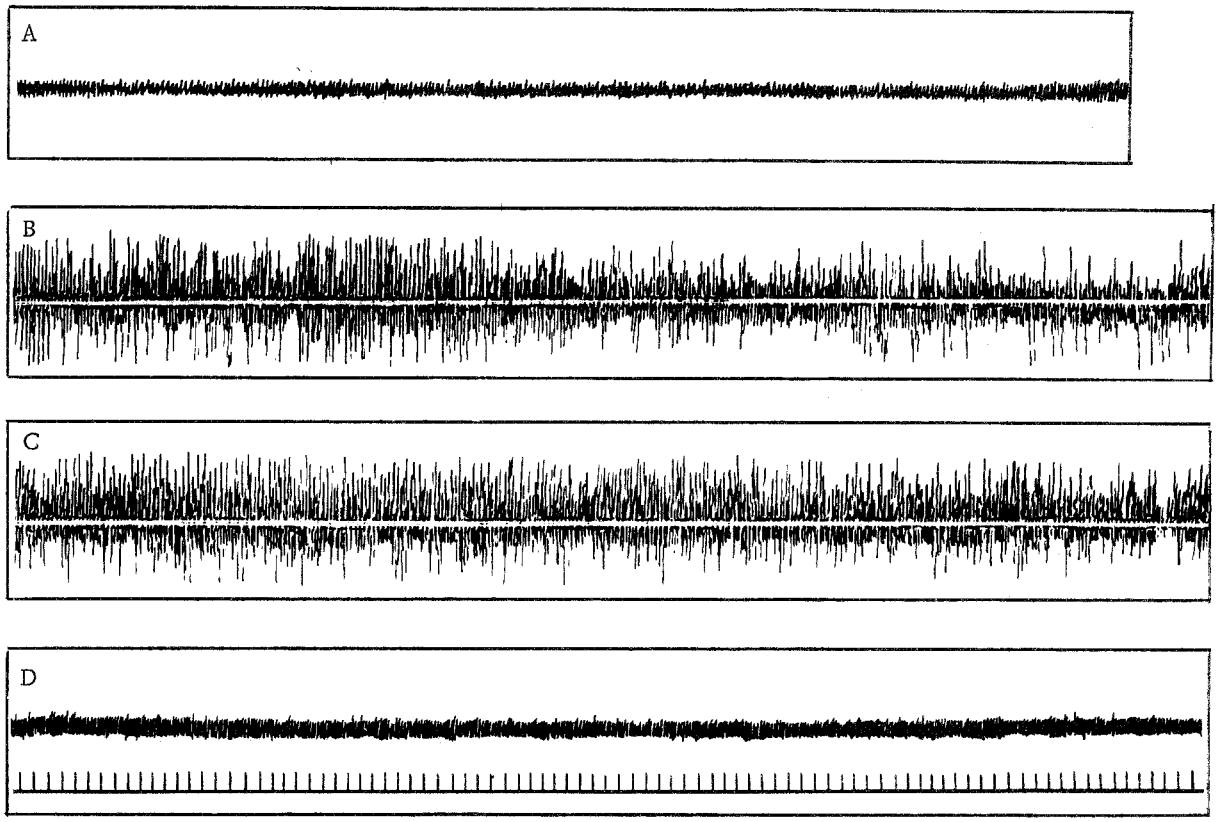

Fig. 2. Change in impulse activity of an afferent nerve of the resected stomach of man as a result of application of caffeine to its mucous membrane. A) Before application; B) 1 minute after application of caffeine; C) after 2 minutes; D) after removal of caffeine from the mucous membrane.

experiments no action potentials from the receptors were found, with the exception of short-lived repetitive action.

Before application of the stimuli, very low background activity was recorded from the receptors and, more often than not, it was totally absent. Several authors [1-3,5] have noted similar features of the activity of the receptors in their oscillographic studies. In response to the action of any of the stimuli used, action potentials made their appearance, or the existing ones were increased. In some experiments we determined a minimal latent period which fluctuated in the range of 30-45 seconds. In several experiments, the activation of bioelectric potentials was obtained only after a longer period of action – after 2-5 minutes.

Not all of the chemical stimuli produced strengthening of the biopotentials with the same constancy. Solutions of glucose and calcium chloride, perfused through the vessels, and caffeine applied to the mucous membrane appeared to be the most effective stimulants. Solutions of peptone and caffeine were less activating when perfused through the vessels, and alcohol was not very effective when applied to the mucous membrane. When the same substance was given, it did not always yield the same result with regard to the height, frequency, and particularities of the grouping of impulses, so that it caused difficulty in any attempt to establish a particular pattern of impulse generation characteristic for each substance employed. But it was possible to observe relatively specific features of the potentials brought out by some substances. Thus, in perfusing with peptone, most often high voltage (50-100μv), 5 to 40-50 per second impulses occurred. These gradually became more rapid, in some cases significantly so (Fig. 1 E,F). With calcium it was more characteristic for potentials with various frequencies of fine tracings to appear, followed by potentials of high frequency. Low voltage potentials, barely exceeding the noise level of the apparatus (5-10μv), were most commonly recorded when alcohol was applied to the mucous membrane. Impulses brought on by vascular perfusion of glucose and topical application of caffeine to the mucous membrane were of a similar character. Both substances, which showed the clearest effects in most of the tests (glucose in 20 out of 22, caffeine in 18 of 20 experiments) elicited very high activity, in which the potentials of rapid frequency attained values of 100μv or more and came either rhythmically or in volleys with amplitudes of 25-50μv (Fig. 1 A, B, and C). In some individual tests, the potentials which resulted from these substances were less

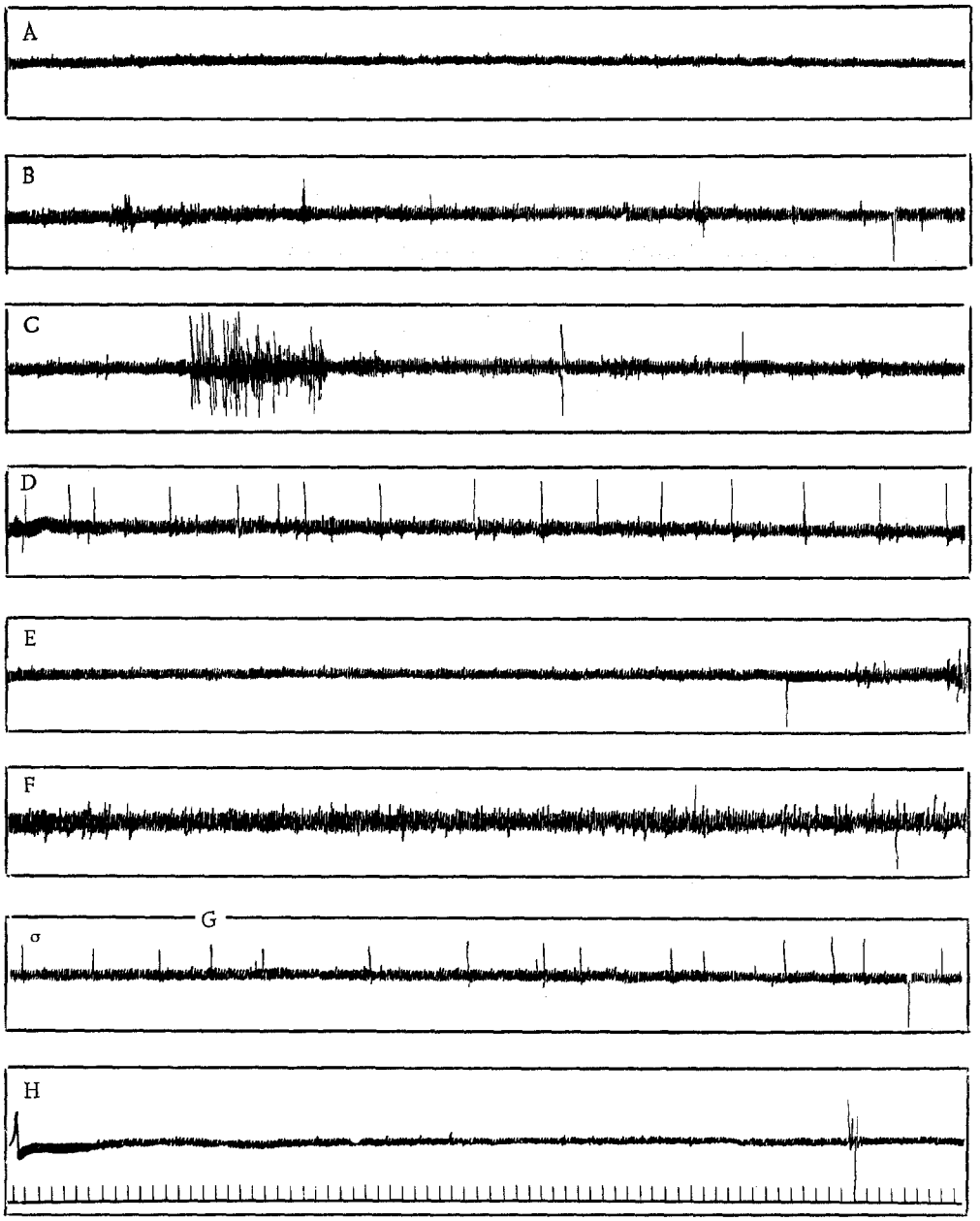

Fig. 3. Change of impulse activity of an afferent nerve of a portion of the small intestine of man during installation in the lumen of peptone and glucose. A) Before peptone; B) 5 minutes after application of peptone; C) 8 minutes after same; D) 3 minutes after washing out of peptone from lumen of intestine; E) before glucose; F) 1 minute following glucose; G) after washing out of glucose from lumen of intestine.

significant. It was shown that the impulses elicited by the application of caffeine to the mucous membrane of the stomach were greater than the activity produced by perfusion of this agent through the blood vessels. This effect was so clear-cut that it could be used as a test for the identification of an active afferent nerve at the beginning of the experiment. (Fig. 1H, J; Fig. 2 A, B, C, and D).

Potentials were recorded from the receptors of the small intestine when glucose and peptone were placed in the lumen. During this procedure rapid potentials occurred which did not exceed 15-25μv. Zamyatina [3] has recorded similar impulses from the intestinal receptors of animals. In addition to the low voltage impulses, potentials of high amplitude (50-100μv) and frequencies of 4-6 per second were also registered (Fig. 3).

SUMMARY

The authors studied the chemoreceptions of the human stomach and small intestine removed during surgery.

The impulse activity in the peripheral section of the afferent nerve was recorded in conditions of perfusion of these organs. Administration into the vessels and application to the mucosa of these organs, of various chemical substances (solutions of glucose, peptone, calcium chloride, caffeine, and alcohol), promoted the appearance of the previously absent impulsation, or enhanced it. The impulses, from 5-10μv to 100μv and over, were either individual with a definite rhythm, or grouped in the form of an uninterrupted series. There were no marked differences in the impulsation resulting from the action of various substances. The greatest activity was recorded with the introduction of glucose into the vessels and with the application of caffeine upon the mucous membrane. The data presented point to the possibility of using certain human internal organs, removed during surgical operations, for the electrophysiological study of different types of reception.

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