IMPLANTATION OF NONPOLARIZING ELECTRODES FOR RECORDING VERY SLOW POTENTIALS OF THE GASTRO-INTESTINAL TRACT UNDER CHRONIC EXPERIMENTAL CONDITIONS

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The article describes the results of implantation of Ag–AgCl nonpolarizing electrodes, capable of recording slow electrical potentials, into the stomach wall and parenchyma of the liver.

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In chronic experiments on dogs performed earlier in our laboratory the potentials accompanying rhythmic contractions of the digestive organs were studied [1, 2, 4, 5]. A technique of implantation of metallic electrodes into the wall of the organ of our own invention, together with an ac amplifier with a narrow frequency transmission band, was used in these experiments [3].

The very slowly changing potentials accompanying processes in the digestive system such as the secretory activity of glands or tonic contractions of the smooth muscles are no less interesting to the physiologist or diagnostician. These very slow potentials cannot be recorded by means of metallic electrodes of the polarizing type. In acute experiments such potentials are recorded by means of nonpolarizing electrodes. In chronic experiments, however, because nonpolarizing electrodes cannot be adapted for implantation, these potentials have been recorded only from the surfaces of the stomach and intestine.

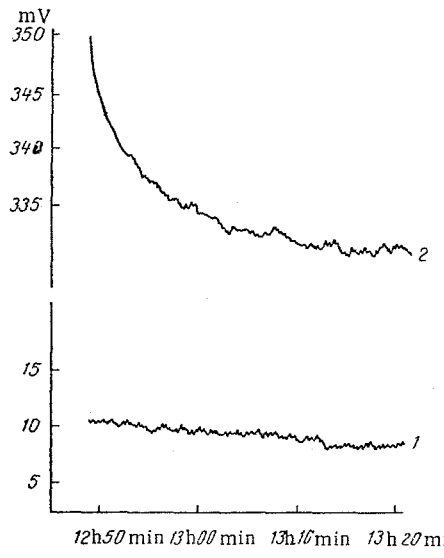

Fig. 1. Parallel recordings of biopotentials by means of Ag–AgCl (1) and Ag (2) electrodes implanted into the pancreas. Experiment on the dog Seryi performed on the day after operation. Upward displacement of the curve corresponds to an increase of the negative potential at the recording electrode.

We felt that there were good prospects for using nonpolarizing Ag–AgCl electrodes for implantation. The Japanese worker Ono [6] implanted Ag–AgCl electrodes temporarily into the wall of the stomach and intestine of human patients during operations. Without discussing the ethical aspects of this worker's technique, we must point out, however, that he recorded only the fast potentials which do not create the conditions for polarization, and he did not therefore observe to what extent the electrodes retain their nonpolarizing properties with the passage of time after implantation.

In experiments on dogs we investigated the possibility of implanting Ag–AgCl electrodes into the digestive organs, paying special attention to the time during which they preserved their nonpolarizing properties.

The electrodes were made in the form of silver disks to which a thin, single-stranded wire insulated with polyvinyl chloride was soldered. The junction was covered with insulating epoxide resin. To exteriorize the free ends of the wires from the abdomen, we used a plexiglass contact

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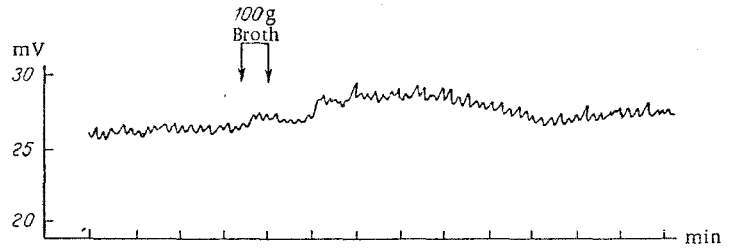

Fig. 2. Fluctuation of potential on electrogastrogram after taking food. Experiment on the dog Tsygan performed 2 days after operation.

socket of our own design fitted with metallic sockets for plugs [5]. One such plexiglass contact socket had leads from several electrodes.

On the day before the operation the electrodes were coated with a film of silver chloride by the galvanic method, and they were kept along with the socket in a warm bath of physiological saline containing penicillin. Only the surface of the contact socket containing the metallic sockets for the plugs remained out of the solution.*

In our experiments on three dogs the electrodes were implanted into the stomach wall and also into the parenchyma of the liver and pancreas. Control polarizing electrodes were also implanted (at a short distance away from the nonpolarizing electrodes) into these organs. They consisted of silver disks of the same size and shape, not coated with silver chloride.

The potentials detected from the same organ by means of the Ag–AgCl and Ag electrodes were recorded simultaneously by two type N-373 ac amplifiers. Under these recording conditions their internal impedance was 500 kΩ. Unipolar leads were used, the indifferent nonpolarizing electrode being applied to a shaved area of skin in the sacral region. Potentials were recorded daily throughout the postoperative period.

The traces obtained on the first few days after the operation showed the following characteristics (Fig. 1). Immediately after the operation a potential difference of a few millivolts was detected between the active Ag–AgCl and indifferent electrodes. On the following days this difference gradually increased by 20-30 mV, the active electrode becoming more negative. Meanwhile the initial potential difference between the active Ag and indifferent (Ag–AgCl) electrodes fluctuated on different days, but was always of the order of several hundred millivolts, and the active electrode was negative. On electrograms obtained by means of polarizing active electrodes the level of the steady component gradually changed in a similar manner to the zero drift. On the other hand, on the electrograms recorded by means of nonpolarizing active electrodes, no such drift was present or it was hardly perceptible.

In order to compare the conductivity of the polarizing and nonpolarizing electrodes, in an experiment on one dog on the 4th day after the operation a weak direct current was passed through the animal's body. This current was fed into the recording instruments simultaneously from the Ag–AgCl and the Ag electrodes. The strength of the current recorded from the Ag–AgCl electrode was 3-5 times greater than that of the current recorded from the Ag electrode (the potentials were almost identical).

From the 6th-7th day after the operation the quality of the records obtained with active Ag–AgCl electrodes varied considerably. A marked "drift" appeared, and the potential difference (mean level of the steady component) increased by 10 times or more. Both these phenomena indicated that the electrodes had lost their nonpolarizing properties. A characteristic sign of this change was the appearance of sudden upward movements on the electrograms associated with mechanical movements: gastric peristalsis, respiratory excursions, or movements of the animal's whole body.

We tried to restore the lost property of nonpolarization to the electrodes in vivo. Twenty days after the operation the implanted electrodes were given a fresh coating of AgCl in a special way. A weak direct

*Immersion of the metallic sockets in the solution rapidly destroys the AgCl film because of generation of a galvanic current in the system.

current was passed through the dog's body for 90 min, the implanted electrode showed signs of loss of nonpolarizing properties being connected to the anode of the source of current, while a silver disk placed on the skin was connected to the cathode. With the values of voltage (6 V) and strength (1-2.5 mA) of the current used, no disturbance or other outward signs of adverse effect from the current were shown by the dog during or after the experiment. When the electrodes were coated again with AgCl by this method, on the following days electrograms could be obtained under the same conditions of recording as before which were free from the peaks described above and which showed a reasonably low potential difference. This method of silver chloride application in vivo does not completely restore the property of nonpolarization of the electrodes.

At autopsy, performed on dogs sacrificed not earlier than 16 days after the operation, macroscopic and histological investigation of the sites of implantation revealed the usual process of encapsulation of a foreign body, with no significant difference between the reactions of the tissues around the Ag–AgCl and Ag electrodes.

In the period during which the electrodes preserved their property of nonpolarization we investigated the action of certain food stimuli on the electrical activity of the stomach. As Fig. 2 shows, after 100 g broth had been taken by the dog a small negative wave of potential appeared on the electrogastrogram. Waves synchronous with the gastric peristalsis were superposed on this slow wave. Attempts to prolong the period of service of implanted nonpolarizing electrodes are promising.

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