Electromyography of the Intestines by the Intra-intestinal Method

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A U-loop bipolar collar electrode was devised for the use in electromyography of the intestines via the mouth or rectum. The findings in animal and clinical experiments were presented. The pattern of action potentials obtained by the intra-intestinal method using this U-loop bipolar collar electrode was almost the same as that recorded by the ordinary extra-intestinal method with laparotomy. With the extra-intestinal method, the maximum amplitude was 1.2 mV, average amplitude 0.3 mV, burst duration 1.2-1.5 sec, spike number 10-11, and burst interval 12.8 sec, while with the intra-intestinal method, the maximum amplitude was 0.66 mV, average amplitude 0.34 mV, burst duration 1.2-1.5 sec, spike number 10-11 and burst interval 12.8 sec.

The pattern of action potentials of the small intestine obtained by swallowing the electrode and that of the large intestine obtained rectally were found to be quite similar to those at the same sites recorded by the extra-intestinal method.

It would be highly advantageous if the electromyogram of the intestines could be accurately recorded by a non-surgical intra-intestinal method. The field of its clinical application would be greatly widened. Various types of electrodes have been constructed and several methods have been devised but none of these have as yet proved entirely satisfactory.

Attempts had been made to record the electromyogram by an intra-intestinal method in our department, and recently, quite constant action potential patterns were successfully obtained by the oral and rectal routes using a modified form of the U-loop bipolar collar electrode used in electromyography of the ureter.\(^1\)

The electrode and method of its use are described and the results obtained are presented in this paper.

METHODS AND MATERIALS

In animal experiments 5 adult dogs were used, and in clinical experiments, 2 subjects with no disorders of the digestive tract and 8 healthy individuals.

The U-loop bipolar collar electrode used in the present experiments was basically of the same construction as that used in electrouretography.\(^1\) An F8 ureteral catheter, 2.5 m in length was used. Silver wire, 0.3 mm in diameter, was

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wound around the catheter in the form of a ring at a site 8.5 cm from the tip and a similar ring placed 1 cm proximal to it to form a bipolar electrode with an interpolar distance of 1 cm. Two small holes were then made in the catheter 5 and 13 cm from the tip. A nylon string was introduced in the catheter from the open end, passed out through the proximal hole and in again through the distal hole; and firmly fastened (Fig. 1). An arch was formed between the holes so that this part came in close contact with the intestinal wall when the string was pulled.

The experiments were conducted according to the following three methods.

1. Extra- and intra-intestinal electromyography in the laparotomized dog

In order to compare the patterns of action potentials obtained by the extra- and intra-intestinal methods, the abdomen of the dog was opened, the jejunum exposed and a small hole (about 1 mm in diameter) which would permit passage of the F8 ureteral catheter was made through the wall of the intestine.
The U-loop bipolar collar catheter was passed cranially into the lumen of the intestine through this hole, for a distance of about 20 cm, the nylon string pulled and the electrode placed in contact with the intestinal mucosa (Fig. 2). Two needle electrodes were then fixed on the serosal surface of the muscular layer of the intestinal wall at the site adjacent to the U-loop bipolar collar electrode. Electromyograms were then recorded through these two leads.

2. Extra- and intra-intestinal electromyography in laparotomized human subjects

Electromyograms were recorded through the two leads described above in 2 human subjects undergoing laparotomy and the patterns of action potentials obtained were compared.

3. Intra-intestinal electromyography by the oral route

Healthy human subjects were first instructed to swallow a duodenal sound and after ascertaining that the tip had reached to the proximal portion of the jejunum, the U-loop electrode was passed down through the duodenal sound. By this method, it was always possible to make sure that the electrode had reached to that portion of the jejunum. The electrode was then placed in close contact with the surface of the intestinal mucosa by pulling the nylon string (Figs. 3 and 4).

4. Intra-intestinal electromyography by the rectal method

The following method was used in recording non-surgically the electromyogram of the colon. A rectal sound was introduced to a depth of 30–40 cm from the
Fig. 4. Placement of U-loop lead.
†: Site of electrodes

Fig. 5. Rectal method of intra-intestinal lead.
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anus, and the U-loop electrode passed through the sound so that the electrode portion of the U-loop reached to the colon. The electrode was then placed in contact with the mucosal surface of the colon by pulling the nylon string (Fig. 5).

The '2-Channel Biophysical Pre-Amp' and the '4-Channel Electrocardiograph' (Nihonkoden Co., Ltd.) were used in electromyography, and recording was made by the heat-writing system with a time constant of 0.03 sec.

RESULTS

In general, when the contractions of the intestine were macroscopically invisible, a straight, flat, linear pattern was obtained in the intestinal electromyogram, but 2-3 minutes after intravenous injection of 5 mg of thiamine tetrahydrofurfuryl disulfide (TTFD), the contractions became visible and typical spike bursts appeared in the electromyogram.

1. Extra- and intra-intestinal electromyograms in the laparotomized dog

Consistent results were obtained in all of the 5 adult dogs. Typical electromyograms by the extra- and intra-intestinal methods are illustrated in Fig. 6. The action potentials recorded with the needle electrodes were: maximum amplitude, 1.3 mV; its average, 0.68 mV; burst duration, 0.60-1.05 sec; and spike number, 4-2. With the U-loop electrode: maximum amplitude, 0.6 mV; its average, 0.49 mV; duration, 1.45-0.60 sec; and spike number, 4-2 (Fig. 6, Table 1). It can be seen that although a slight decrease in amplitude is recorded by the intra-intestinal method, there is almost no difference in the other aspects between the two records.

2. Extra- and intra-intestinal electromyograms in the laparotomized human subject

A typical electromyogram in a laparotomized human subject is illustrated

![Fig. 6. Extra- and intra-intestinal electromyograms in dog (laparotomized)](image)

Upper: Intra-intestinal lead  Lower: Extra-intestinal lead
in Fig. 7. In this case, the action potentials recorded by the extra-intestinal method were: maximum amplitude, 1.2 mV; its average 0.3 mV; burst duration, 1.2–1.5 sec; and spike number, 10–11. With the intra-intestinal method: maximum amplitude, 0.66; its average, 0.34; duration 1.2–1.5 sec; and spike number, 10–11. Thus, the results obtained with the extra- and intra-intestinal methods were similar to those obtained from the animal experiments (Fig. 7, Table 1).

3. *Intra-intestinal electromyograms by the oral method*

Three of the 5 cases showed typical patterns in the intra-intestinal electromyograms taken by the oral method (Fig. 8). The results obtained coincided well with those obtained in the laparotomized cases (Table 1).
4. Intra-intestinal electromyograms by the rectal method

All 3 cases examined with the rectal method showed also the typical patterns (Fig. 9, Table 1).

DISCUSSION

The attempt to observe the movements of the intestine electro-biologically was made first by Alvarez and Mahoney in 1922. They tried to record the action current of the digestive tract but the patterns obtained were incomplete. Later, Bozler undertook similar studies using the excised intestine and made a valuable contribution to our knowledge in this field.

Various pathological conditions of the intestines have been studied electromyographically, by measuring the action potential from the serosal surface under laparotomy. For wider clinical application, however, location of the electrode at the desired site without surgical manipulations is desirable. Ueda and Suzuki devised the ‘balloon’ catheter for this purpose and reported that a pattern similar to that recorded by extra-intestinal lead was obtained by introducing this catheter into the colon via the anus. In the present study, the patterns of action potentials similar to those reported by Suzuki and Iwamatsu in man and dogs were obtained by introducing a U-loop electrode into the small intestine via the mouth and into the colon via the anus. This suggests the usefulness of the present method in investigation of pathophysiology of the intestines.

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References


