Minute Rhythms of Spike Activity in Intestinal Smooth Muscles during Transition Processes

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A more informative method of transforming electromyograms to assess the spike activity of intestinal smooth muscles is proposed. The presence of minute rhythms of spike activity during the transition from the resting phase to regular activity is confirmed. These rhythms are recorded in the proximal part of the small intestine during the irregular phase of fasting periodic activity. It is found that the appearance of minute rhythms of spike activity on days 3-4 of modeled peritonitis may mark the beginning of the transition from pathology to health and indirectly indicate the regression of the pathological process.

Key Words: *gastrointestinal tract; minute rhythms; action potential; electromyography; fasting periodic activity*

The motorics of the gastrointestinal tract during fasting periodic activity is represented by phases of rest and of irregular and regular activity [4]. The presence of minute rhythms in the proximal segment of the small intestine during the phase of irregular activity has been demonstrated [2]. In addition, some researchers [3] have observed this rhythm in various pathologies, specifically, in irritable bowel syndrome. It should be noted that these data were obtained mainly by measuring intracavital pressure with the use of an open catheter [1]. There are few studies in which this rhythm has been recorded as bursts of action potentials (AP) when electrical activity was studied electromyographically.

In contrast to intracavital pressure records, electromyograms are represented by low-frequency oscillations at slow-wave (SW) frequencies and by action potentials of varied amplitude and shape on the SW crests. It should be remembered that during extracellular measurement the shape and amplitude of each AP depend on the site of formation and the distance that the AP wave travels from the site to the recording electrodes. This accounts for the diversity of spike activity forms, which hampers an objective evaluation of the intensity of AP generation in gastrointestinal smooth muscle cells.

Our objective was to study minute rhythms of spike activity in the small intestine in health and in experimental pathology by transforming electromyograms with the use of special equipment and designated computer software.

MATERIALS AND METHODS

Experiments were performed on mongrel dogs. A PEG-8 bipolar electrode (Russia) was inserted subserously in the jejunum 50 cm distal to the Treitz's ligament.

The electrical activity of the jejunum segment was studied in 10 healthy dogs fasted for 18 h and in 8 dogs with experimental peritonitis. Peritonitis was modeled by intraperitoneal injection of a 30% suspension of feces in a dose of 0.5 ml/kg body weight.

Special equipment and software were developed to evaluate the spike activity more objectively. The set-up consisted of a high-frequency filter with a cutoff band <0.5 Hz (to separate only AP without SW), a detector (to invert negative AP), a logarithmic amplifier (to amplify high-amplitude AP slightly

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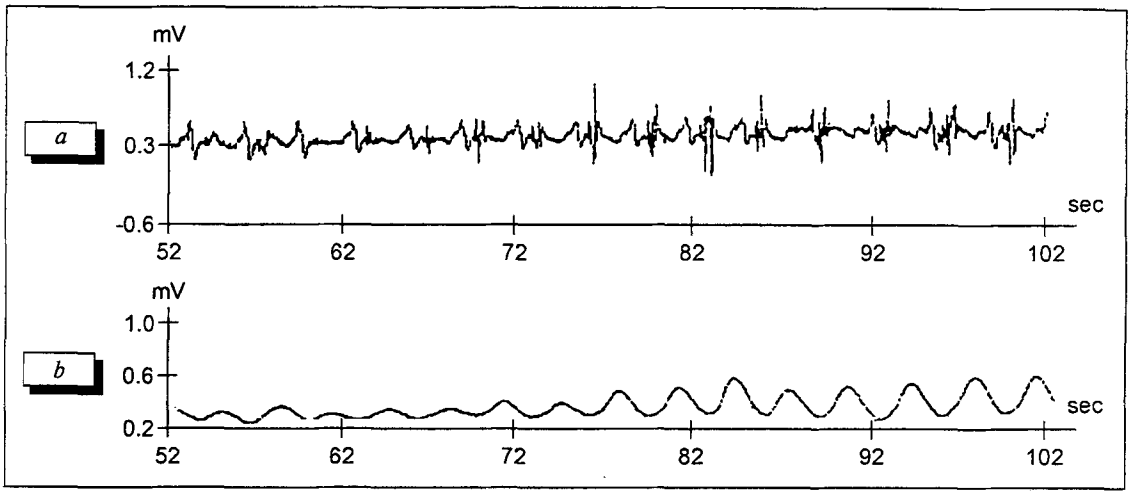

Fig. 1. Synchronous record of electrical activity without transformation (*a*) and with transformation (*b*).

and low-amplitude AP markedly), and a low-frequency filter (for averaging the areas of transformed AP with a time constant corresponding to SW). Thus, a signal was recorded at SW frequency and represented periodic and gradual modulation of spike activity. Figure 1 shows a synchronized record of electrical activity with and without transformation. Low-frequency oscillations with SW frequency were observed in the transformed curve only in the presence of AP on SW crests in the initial curve.

RESULTS

In the first series of experiments, we studied the electrical activity of the proximal segment of the small intestine in intact dogs. Changes in the intensity of spike activity reflected different phases of fasting periodic activity. The resting phase lasted 50±10 min, the irregular activity phase 12±2 min, and the regular activity phase 6±1 min. A minute rhythm in the form of clusters of AP bursts lasting 53±5 sec was observed in the irregular phase. Figure 2 shows a fragment of the minute rhythm recorded electromyographically with and without transformation of spike activity. Undoubtedly, the transformed electromyogram reflects the dynamics of intestinal spike activity more clearly. Figure 3 is a 30-min record of spike activity during fasting periodic activity. It illustrates the emergence of a minute rhythm during the transition from the resting phase to phase of regular activity.

In the second series of experiments, we studied the electrical activity in experimental peritonitis. In 5 surviving dogs, electrical activity from day 1 was represented predominantly by the irregular phase with a half-minute rhythm (25±5 sec). On days 3-4, the correct minute rhythm (50±5 sec) was restored, and regular phases of normal activity were recorded. "Irregular phase - regular phase - resting phase" complexes were recorded on day 6. The irregular phases were longer (33±3 min) than in intact animals. However, the duration of regular phases and of the entire cycle of fasting periodic activity was restored by day 6. It should be noted that in the three animals which died, spike activity was markedly suppressed

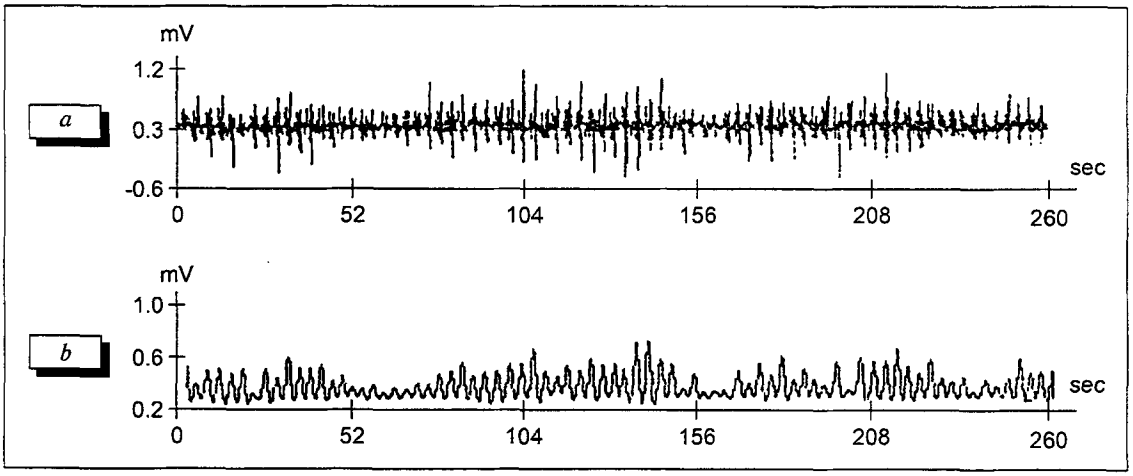

Fig. 2. Minute rhythms of spike activity. Electromyogram without transformation (*a*) and with transformation (*b*).

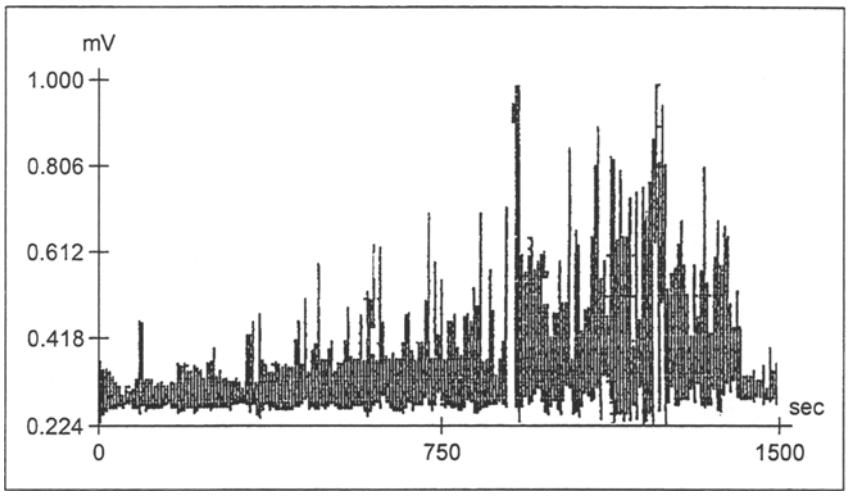

Fig. 3. Electrical activity during fasting periodic activity (transformed electromyogram).

and minute rhythms were not observed from the time of injection of the suspension to their death.

Thus, our results indicate that the proposed method yields a more informative evaluation of the spike activity of intestinal smooth muscles, confirming the presence of minute rhythms of spike activity during the transition from the resting phase to the phase of regular activity such as are recorded in the proximal portion of the small intestine during the irregular phase of fasting periodic activity. The appearance of minute rhythms during transition processes is probably associated with the metabolic preparation of the studied segment for active work. The appearance of minute rhythms on days 3-4 of modeled peritonitis may mark the initial stage in the transition from pathology to health and serve as an indirect indication of regression of the pathological process.

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