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The Myoelectric Activity of the Small Intestine of the Dog during Total Parenteral Nutrition[1, 2] (39493)

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Total parenteral nutrition (TPN) is used clinically in the management of patients who cannot adequately assimilate food stuffs from the gastrointestinal (GI) tract (1). Experimentally, TPN is useful as a tool to investigate the role of total oral food deprivation on the physiology and morphology of the GI tract. Previous studies in several laboratories have demonstrated major changes in GI structure and physiology during prolonged periods of intravenous alimentation. In the rat, the small bowel undergoes hypotrophy, brush border enzymes significantly decrease, and serum and antral gastrin concentrations are diminished (1-3). However, little is known of the effects of TPN on motility of the GI tract.

Motility patterns of the small intestine can be determined by studying its myoelectric activity, which consists of two basic types of potentials: slow waves, or basic electric rhythm (BER), and spike potentials. Descriptions of these two potentials and their role in controlling contractions of the bowel have been reported (4). Basically, slow waves control the timing of contractions (when they occur) at any one site and at adjacent sites, while spike potentials signal and initiate the contractions. Spikes appear only during a specific phase of the slow-wave cycle; however, not all slow waves are accompanied by spike potentials. The percentage of slow waves that are accompanied by spike potentials and their temporal distribution depend on the digestive state of the animal. In the fasted dog, a characteristic pattern called the intestinal interdigestive myoelectric complex is present (5). This complex consists of four phases. In phase I, none of the slow waves is accompanied by spike potentials. In phase II, spike potentials are superimposed on the slow waves in a random fashion. During phase III, every slow wave has superimposed spike potentials. Phase III ends abruptly (phase IV) and phase I repeats. These phases not only occur at one particular site, but appear to propagate aborally along the bowel. Feeding the dog abolishes this complex and produces a more uniform distribution of spike potentials superimposed upon slow waves, which has been called the fed pattern of activity. The exact percentage of slow waves with spike potentials depends on the type of food given and on the region of bowel being monitored (6). The purpose of this study was to determine the intestinal motility patterns in dogs maintained by TPN.

Materials and Methods. Three dogs, two male and one female, were used. Each animal was anesthetized with thiopental sodium (20 mg/kg) and methoxyflurane. A laparotomy was done, and 14 electrodes were sewn onto the serosal surface of the small intestine. The monopolar, silver-wire electrodes were spaced equidistant (about 25 cm apart) along the entire bowel from the gastroduodenal junction to the ileo-cecal junction. A coil of silver wire was placed subcutaneously in the right flank to serve as a reference electrode. Details for constructing and implanting similar electrodes have been reported (7). During the same operation, a sterile Polyvinyl catheter (i.d. 0.03 in.) was placed in the superior vena cava through a cut down in the external jugular

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vein. The wires from the electrodes as well as the superior vena cava catheter were tunneled subcutaneously to exit at the midscapular region. Immediately following surgery, each animal was placed in a harness which allowed for almost complete freedom of movement as well as continuous infusion of intravenous fluids (8). The only movement the animal could not make within the harness was to roll over on his back. The dogs were taken from their cages for daily exercises and for periodic recordings of myoelectric activity.

Electrical potential changes between the electrodes and the reference coil were recorded separately with a Beckman Type R-411 Dynagraph through the resistor–condensor input of 9806A couplers at a time constant of 1 sec. The upper or high-frequency cut-off control was set at 100 Hz. Recording sessions were 2 to 4 hr in length.

Recordings were begun 10 to 14 days after operation and after complete recovery of the animals. Control recordings were made during a 3-week period while the animals were receiving saline intravenously and canned dog food orally (prescription diet, Riviana Foods, Topeka, Kansas). Records were obtained from conscious animals after an 18-hr fast (control fasting pattern) or immediately following feeding of one can of dog food (control fed pattern). Following the control period, oral food was discontinued and TPN was begun. TPN was maintained for 6 to 11 weeks during which time recordings were made at least once weekly. Then TPN was stopped, oral food was given, and recordings were made in both the fasted and fed state for a period of 3 to 5 weeks.

To determine the temporal distribution of spike potential activity, the number of slow waves with superimposed spike potentials was counted during each 2-min interval of the experiment, divided by the total number of slow waves which occurred during the same 2-min interval, and expressed as previously described (9). The intervals between phase 4 of the complexes and the mean percentage of slow waves accompanied by spike potentials in the fasted state, under the conditions of pre-TPN, during TPN, and post-TPN were compared by analysis of variance. The means of the percentage of slow waves accompanied by spike potentials in the fed state before and after TPN were compared by the paired t test.

Results. Pre-TPN. Recordings from two of the animals indicated that normal fasted and fed patterns of small bowel myoelectric activity were present. The periodicity of the myoelectric complexes and percentage of slow waves with spike potentials during fasting are presented in Tables I and II. The complexes were interrupted and replaced by a more uniform activity after feeding. The fed pattern was also characterized by a larger percentage of slow waves which were accompanied by spike potentials (Table II). In the other animal (Dog A), abnormal activity was present during the fasted state. Myoelectric complexes were evident but their timing was irregular, and phase I of the complexes usually was absent. The fed pattern in this animal was normal (Table II).

During TPN. The animals were maintained on TPN for a period of 9 weeks (Dog A), 6 weeks (Dog B), and 11 weeks (Dog C). During this time the animals experienced minimal changes in body weight (−2, +1, and + 1 lb, respectively). A total of 60 recordings were done on the three dogs during a total of 26 weeks of TPN. Completely normal interdigestive myoelectric complexes were recorded in 83% of the tracings (50 out of 60). A selected tracing from each animal during the last week of TPN was analyzed and is presented in Fig. 1. The periodicity of the complexes and the average percentage of slow waves with spike potentials are presented in Tables I and II. There were no differences between the fasted control pattern and the pattern seen during TPN. In 17% of the tracings (10

TABLE I. MINUTES BETWEEN PHASE 4 OF COMPLEXES AT ONE SITE

Dog	Pre-TPN	During TPN	Post-TPN
A	–[a]	85 ± 6 (10)	95 ± 4 (4)
B	92 ± 6 (8)[b]	106 ± 7 (15)	101 ± 7 (7)
C	106 ± 3 (5)	119 ± 8 (25)	111 ± 12 (5)

[a] Value not included due to presence of intestinal parasites. Analysis of variance indicated $P > 0.10$ for the three conditions.

[b] Values represent the mean ± SEM. Values in parentheses indicate number of daily tracings analyzed.

TABLE II. MEAN PERCENTAGE OF SLOW WAVES ACCOMPANIED BY SPIKE POTENTIALS AT ONE SITE ON THE PROXIMAL JEJUNUM

	Fasted			Fed	
	Pre-TPN	During TPN	Post-TPN	Pre-TPN	Post-TPN[a]
A	—[b]	26 ± 2 (10)	24 ± 2 (4)	42 ± 3 (3)	37 (1)
B	24 ± 4 (8)[c]	18 ± 2 (15)	17 ± 2 (7)	44 ± 1 (3)	32 (1)
C	17 ± 3 (5)	23 ± 2 (25)	23 ± 3 (5)	37 ± 2 (3)	39 (1)

[a] Values are for first feeding after TPN. Analysis of variance of data for the fasted condition indicated $P > 0.10$. Paired t test of data for the fed condition indicated $P > 0.10$.

[b] Value not included due to presence of intestinal parasites.

[c] Values represent the mean ± SEM. Values in parentheses indicate number of daily tracings analyzed.

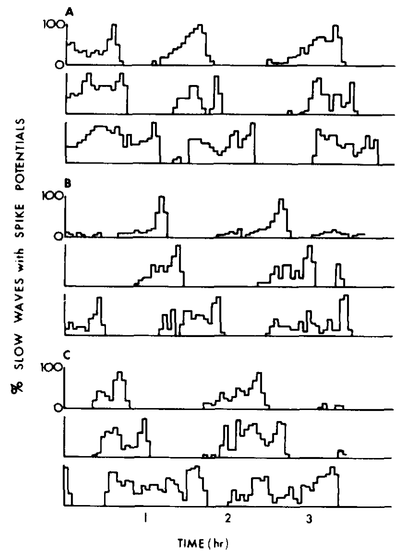

FIG. 1. Temporal distribution of slow waves with spike potentials during TPN. Tracings from three electrodes in each animal (Dogs A, B, and C) were analyzed. Percentage of slow waves with spike potentials in each 2-min interval is on the Y-axis; time in 2-min intervals is on the X-axis.

recording periods), the myoelectric complexes were present but their timing was abnormal and phase I was absent. Data obtained from Dog A were included in this report because the reason for the abnormal pre-TPN myoelectric patterns became evident during the experiment. On the second day of TPN, the animal passed a stool, tarry in appearance and containing numerous hookworm eggs. After treatment of the infection, by oral administration of thenium closylate, 500 mg, normal interdigestive myoelectric complexes returned.

Post-TPN. Resumption of normal feeding was followed immediately by the appearance of the fed pattern of motility in all three animals. Figure 2 illustrates the results of the first feeding after 11 weeks of hyperalimentation (Dog C). All of the animals tolerated resumption of oral food and no vomiting or diarrhea was evident. The fasted pattern of myoelectric activity in each dog was also identical to that seen for both before TPN (Tables I and II). The fed pattern of activity was the same both before and after TPN.

Discussion. An essentially normal fasted pattern of myoelectric activity was the only pattern recorded from the dog during a maximum of 11 weeks of TPN. The reasons for the presence of the interdigestive myoelectric complex during a prolonged period of TPN are not known. In fact, the function

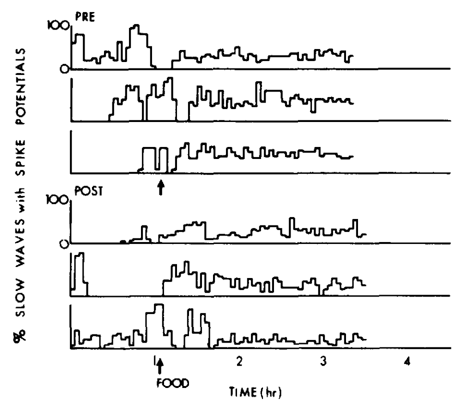

FIG. 2. Temporal distribution of slow waves with spike potentials. Tracings from three electrodes in Dog C. The top tracings (PRE) were made before initiation of TPN; the bottom tracings (POST) were made on the last day of TPN when the animal was fed for the first time. In both cases, the animal was fasted at beginning of experiment. At time indicated by the arrow, the animal was fed one can of dog food.

of the interdigestive myoelectric complex during the short-term fasted periods between oral nourishment is not known. Code (10) has suggested that this complex could serve as an "interdigestive housekeeper" which maintains the small intestine free of accumulated secretions and ingested debris. Possibly, this fasted activity may prevent bacterial overgrowth within the small intestine.

Castro *et al.* have demonstrated that several changes occur in the small intestine of the rat during periods of at least 6 days of TPN (2). A change in the diameter of the small intestine during TPN has also been observed in the dog (personal observation). Although hypoplasia of the small intestine may occur during nutritional maintenance with TPN, the myoelectric activity of the small bowel did not change. Similarly, the elicitation of a fed pattern of motility immediately following the ingestion of food indicated that the mechanism responsible for conversion from the fasted pattern was not impaired during TPN. The factors responsible for conversion of the fasted to the fed pattern following eating are unknown. The fact that the fed pattern does not occur during TPN indicates that the presence of nutrients in the blood is not responsible for the conversion. Thus, events which occur due to the actual presence of food in the GI tract must be important. Release of the hormone gastrin has been implicated in the conversion (11). Since serum and antral gastrin concentrations are thought to be depressed during long intervals of "bowel rest," as occurs with TPN (12), gastrin may not have been available to participate in the conversion from fasted to fed patterns in our experiment.

The capacity of an animal to assimilate food immediately following a prolonged period of TPN has been questioned because several investigators have demonstrated that brush-border hydrolytic enzymes are depressed during nutritional maintenance with TPN (2, 3). Nevertheless, each animal in our experiment ate canned dog food without ill effects immediately after TPN was terminated.

Summary. The myoelectric activity of the small intestine was monitored in conscious dogs before, during, and after periods of total parenteral nutrition (TPN). Before TPN, each animal displayed two distinct patterns of myoelectric activity. One pattern was seen in an animal that had been fasted for 18 hr (the interdigestive myoelectric complex); the other pattern was seen after feeding (fed pattern). TPN was then begun and continued for up to 11 weeks, during which time the animals maintained their weight. During TPN, the only myoelectric pattern evident was the interdigestive myoelectric complex and its characteristics were similar to those seen before TPN. The first oral feeding after TPN was followed by the development of a fed pattern. We conclude that: (1) The fasted pattern of myoelectric activity is present during prolonged periods of food deprivation. (2) The presence of nutrients in the blood is not the factor required for presence of the fed pattern. (3) The factors responsible for development of the fed pattern are not impaired by oral food deprivation.

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