AMERICAN JOURNAL OF PHYSIOLOGY
Vol. 226, No. 6, June 1974. *Printed in U.S.A.*

Correlations between ionic contents in different regions and layers of intestinal muscle

DONALD D. JOB AND WILLIAM E. BLOOMQUIST
Lilly Research Laboratories, Eli Lilly and Company, Indianapolis, Indiana 46206

JOB, DONALD D., AND WILLIAM E. BLOOMQUIST. *Correlations between ionic contents in different regions and layers of intestinal muscle.* Am. J. Physiol. 226(6): 1496-1501. 1974.—A systematic study of the ion content of cat intestinal muscle has been made. Different regions of the small intestine were compared. Differences were also sought between the ion content of the two muscle layers. Only sodium ions exhibited a statistically significant gradient down the intestine, with the ileum being lower than the duodenum. This gradient was present in both layers separately and in combination with each other. Calcium was significantly lower in ileum than in duodenum, but it did not decrease in a linear fashion. Furthermore, this difference was prevalent only in the longitudinal layer. The longitudinal layer was generally higher in sodium, chloride, and calcium than the circular layer. Correlation coefficients were computed for the various ions. Sodium and calcium were significantly correlated, which is in keeping with current concepts of excitable membranes. Sodium and potassium, however, were less highly correlated. A new relation was suggested by finding a high correlation between potassium and magnesium.

longitudinal muscle; circular muscle; intestinal smooth muscle; electrolyte content of smooth muscle; intestinal gradients

NUMEROUS STUDIES on the ionic content of intestinal smooth muscle have been reported (10). However, only two laboratories have reported studies on ion content in the smooth muscle of cat small intestine (3, 4, 17). In both the latter groups, the emphasis was on the circular muscle only. Furthermore, in one case no distinction was made between ileum and jejunum (3, 4). In the other case, it was concluded after a preliminary examination that there were no differences in ion content of the different regions of the intestine (17).

Very little attention has been paid to the possibilities of layer differences and regional differences. However, there is ample evidence that there are regional differences in the small intestine with respect to motility (1, 2, 8, 14) as well as with respect to biochemistry (15). It does not seem unlikely that there is an ionic basis for some of these differences, at least for the differences in smooth muscle motility. This paper and the two accompanying papers (14, 15) explore this possibility.

With respect to layer differences, there are well-documented differences in the electrical behavior of the two muscle layers in small intestine. Prosser and his associates (16) have shown that slow waves arise from the longitudinal layer and spikes are suppressed in the presence of slow waves. The circular layer, on the other hand, in the absence of longitudinal fibers gives rise to spikes but not slow waves (16). It was of interest to see whether these differences might not also be related to ionic differences between the two layers. Portions of the data in the present paper have been presented previously (13).

MATERIALS AND METHODS

Cats of a heterogeneous background and breed were used weighing from 2 to 5 kg and averaging about 2.5 kg. They were anesthetized with α-chloralose (65 mg/kg) before their abdominal cavities were opened. The entire intestinal tract was removed and placed into well-oxygenated (95% O_2-5% CO_2) Tyrode solution. The Tyrode solution had the following composition (in mM): KCl 4.7, NaCl 133, $CaCl_2$ 1.66, $MgCl_2$ 0.22, $NaH_2PO_4 \cdot H_2O$ 1.36, and $NaHCO_3$ 16.0. Also present was 1 g of glucose per liter of solution.

The tissue was cut into five regions. The first region was from the middle of the duodenum. The second region was from the area approximately 5–10 cm below the ligament of Trietz. The third region was 23–28 cm from the ligament. The fourth region was ileum or about 40–50 cm from the ligament, and the fifth region was 5–8 cm up from the ileocecal junction. A 2- to 3-cm segment was taken from each region and freed of fatty tissue. It was then everted and the mucosa and submucosa were stripped off. Following the separation procedure, the segments were equilibrated for 60–90 min in warm (36°C) Tyrode solution. Following equilibration, one piece of the segment was taken directly for ion analysis, rinsed very briefly in distilled water (1–2 s), blotted immediately on Whatman no. 44 filter paper, weighed, and dried. The other piece of the segment was taken for separation of the two layers.

The longitudinal and circular layers were separated by first making two parallel longitudinal incisions about 5 mm apart. The longitudinal layer was then teased apart at one end and pulled up with fine forceps. The underlying circular muscle was then cut out and both preparations were rinsed, blotted, and weighed for wet weights. The samples were dried overnight in an oven at 100°C and reweighed for dry weights. Several weighings at increasing time periods in the oven indicated that overnight drying gave stable dry weights.

Ion determinations were made on a nitric acid (.75 N) extract of the dry tissue using a Perkin-Elmer atomic-absorption spectrophotometer, model 303. Different lamps