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ELECTROSIGMOIDOGRAM, ELECTRORECTOGRAM AND THEIR RELATION

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1. ABSTRACT

The electric activity of the sigmoid colon (electrosigmoidogram=ESG) and rectum (electrorectogram=ERG) and their relationship was studied in nine patients. Slow waves or pacesetter potentials (PPs) of the sigmoid colon and rectum were recorded. The PP frequency and amplitude of the electrorectograms were higher ($p < 0.05$) than electrosigmoidograms. Balloon distention of the sigmoid colon or rectum increased the frequency, amplitude and velocity of PPs and APs proximal to the balloon and led to their decrease distally. These effects were enhanced with increased balloon distention until the balloon was expelled. Balloon distention of the sigmoid colon did not affect the rectal electromechanical activity and vice versa. This study suggests that the movement of the sigmoid colon or rectum is of the “mass type”.

2. INTRODUCTION

Motility of colon moves the colonic contents to the rectum. Colon possesses 3 motor activities; segmentation, massive peristalsis and antiperistaltic movements (1-3). Slow waves or pacesetter potentials (PPs) and bursts of action potentials (APs) have been recorded from different parts of the gut (4-18). Ingestion of food elicits electric activity of the colon under normal physiologic conditions (19,20). Patients with slow-transit constipation showed no colonic myoelectric response to food ingestion (12,21,22).

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The sigmoid colon stores stools and delivers them to the rectum. Although the myoelectric activities of the sigmoid colon and rectum have been separately studied (7,8,14-18), the relation of the electric activity of sigmoid colon to the rectum has not been studied thus far. In this communication, the myoelectric activity of the sigmoid colon and rectum were studied under resting conditions and under a condition that simulated defecation.

3. MATERIAL AND METHODS

3.1. Subjects

Nine subjects (5 men, 4 women; mean ages 48.6 ± 10 SD) were enrolled in the study after having given an informed consent. The study had been approved by our Faculty Review Board. The patients had double-barrel colostomy (left iliac fossa) for malignant tumors of the descending colon 1 to 2 months prior to presentation. Sigmoid colon was preserved in these patients. Patients underwent barium enema to ascertain the functionality of the sigmoid colon. Patients, in whom the colostomy had encroached upon the sigmoid colon, or whose colostomies were performed more than 2 months prior to presentation, were excluded from the study. The physical examination, including neurologic evaluation, was normal. Digital rectal examination was unremarkable.

3.2. Methods

3.2.1. Electric activity studies

Saline enema was done through the colostomy to clean the sigmoid colon and rectum from residual fecal masses. Patients fasted for 12 hours before the examination. The electric activities of sigmoid colon

Figure 1. Electrosigmoidogram showing monophasic pacesetter potentials followed randomly by action potentials.

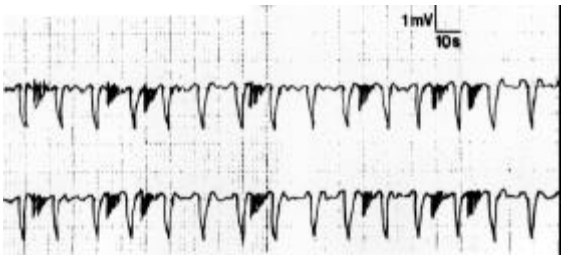

Figure 2. Electrorectogram showing triphasic pacesetter potentials followed randomly by action potentials.

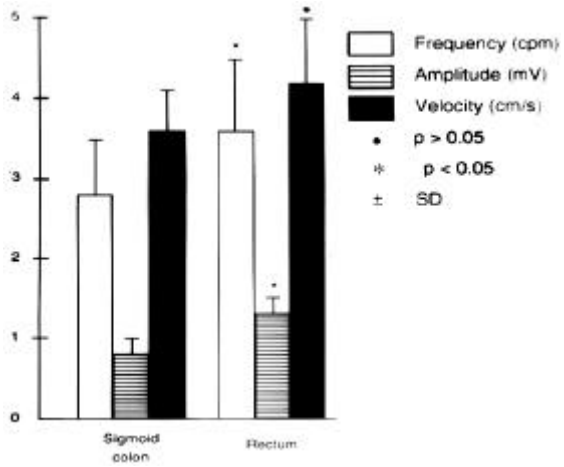

Figure 3. Frequency, amplitude and velocity of conduction of pacesetter potentials recorded from the sigmoid colon and rectum of 9 colostomy patients.

were recorded by a 6 French (F) catheter attached to the sigmoid mucosa by suction with a negative pressure, ranging from 50 to 100 mmHg. Thus pressure was maintained during the course of recordings.

Monopolar recordings were made from silver-silver chloride electrodes (0.2 mm diameter) situated 1 cm from the tip of the catheter. The catheter tip was applied to the sigmoid mucosa, and suction was initiated to maintain the catheter fixed to the mucosa. Signals from the electrode were fed into an AC amplifier with a frequency response within ± 3 dB from 0.016 Hz to 1 kHz. They were displayed on a recorder at a sensitivity of 1 mV/cm. The earthing electrode was a metal disk applied to the abdominal skin.

Two electrodes were applied to the sigmoid colon, and 2 to the rectum. With the patient in the supine position, the 2 catheters were introduced into the sigmoid colon through the colostomy so that one catheter lay 10 cm and the other 15 cm from the mucocutaneous junction of the colostomy. Another 2 electrodes were applied to the rectal mucosa. The patient lay in the left lateral position and the electrodes were introduced into the rectum for 8 and 10 cm from the anal orifice.

3.2.2. Manometric studies

The mechanical activities of the sigmoid colon and rectum were determined by measuring the pressure by means of a 6 F catheter with 2 lateral 2 mm side ports and a closed distal end. One catheter was placed in the sigmoid colon 10 to 15 cm from the mucocutaneous junction of the colostomy and another one in the rectum 8 to 10 cm from the anal orifice. The catheters were infused with 37°C sterile saline at a rate of 2 ml/min. They were connected to strain-gauge pressure transducers (Statham 230 B, Oxnard, California, USA).

Recordings were initiated after 30 minutes to allow the gut to adapt to the electrodes and manometric catheters. Two recording sessions of 180 minutes each were undertaken for the individual subject, each on a different day. During the recording session, the patient was asked to abstain from ingestion of food or fluid.

3.2.3. Balloon distention of the sigmoid colon and rectum

The electric and mechanical activities of the sigmoid colon and of the rectum were also studied upon the balloon distention of the sigmoid and rectum. A balloon simulating stool and made of an unstretched condom (London Rubber Industries Ltd., London, UK) was tied around the end of a 10 F catheter. Two catheters were used: one for the sigmoid colon and the other for the rectum. The lubricated collapsed condom was introduced into the sigmoid through the colostomy and was placed between the two sigmoid electrodes. The other catheter was introduced through the anal orifice into the rectum and was placed between the 2 rectal electrodes.

Each balloon was left in place for 15 minutes prior to the start of recordings to allow for gut adaptation. The sigmoid balloon was then filled with 10 ml of 37°C water. The balloon filling was increased in increments of 10 ml up to 80 ml and the electromechanical response of the sigmoid colon and the rectum to sigmoid distention was recorded. The sigmoid balloon was emptied of water and removed and the subject was allowed to rest for one hour to allow the gut to return to the basal condition. The rectal balloon was then introduced into the rectum and filled with 10 ml of warm water, and the filling was increased in increments of 10 ml up to 100 ml. Then, the electromechanical response of both sigmoid colon and rectum to rectal distention were recorded.

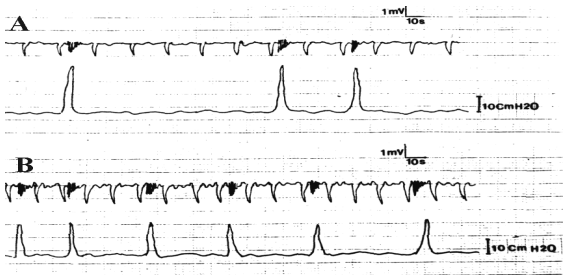

Figure 4. Simultaneous recordings of the electric activity (upper tracings) and pressure (lower tracings) in sigmoid colon (A) and rectum (B). The pressure increased synchronously with the action potentials and not with the pacesetter potentials.

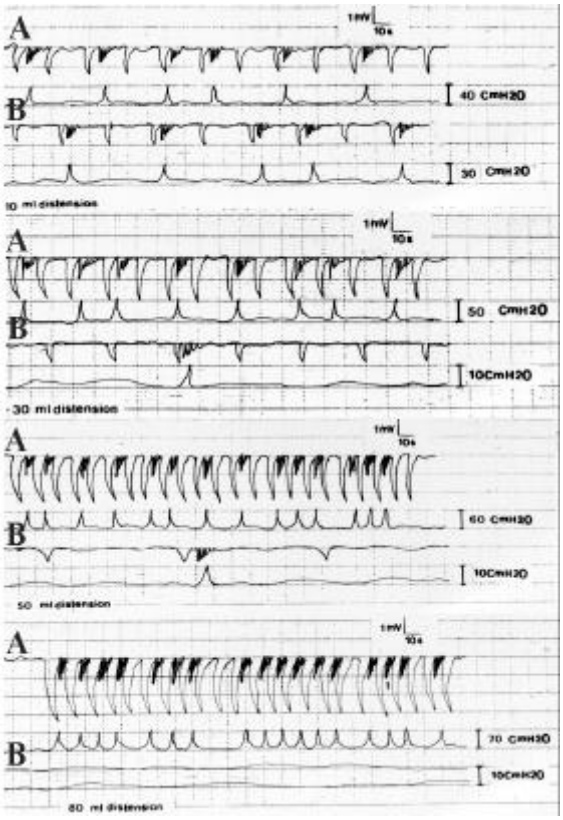

Figure 5. Simultaneous recordings of the electric activity and pressure of the sigmoid colon upon balloon distention with 10 (top), 30 (middle, top), 50 (middle, bottom) and 80 (bottom) ml of water. There was an increase in frequency and amplitude of PPs and APs from the electrode proximal to the balloon (A) and a decrease in these variables from the distal electrode (B). At 80 ml distention, the distal electric activity disappeared. The APs were associated with elevation of the pressure in the sigmoid colon.

Each test was repeated at least twice to ensure the reproducibility of the results. The results were analyzed statistically using the Student's t test. Significance was ascribed to $p < 0.05$. Values were reported as mean ± standard deviation (SD).

4. RESULTS AND DISCUSSION

No complications were encountered during or after performing the tests. The electrodes did not move during recording as long as the proper suction pressure was maintained on the gut wall.

4.1. Electric activity

In the sigmoid colon, slow waves or pacesetter potentials (PPs) were monophasic with a large negative deflection (Figure 1). The rectal PPs were triphasic with a small positive, large negative and small positive deflection (Figure 2). The PPs, either in the sigmoid colon or the rectum, had regular rhythms with identical frequency, amplitude and velocity of conduction when recorded from the 2 electrodes in sigmoid colon or the rectum (Figures 1, 2). These variables were constant on all test days when the examination was repeated in the same subject. However, they were different in the sigmoid colon from the rectum (Figure 3). The frequency and amplitude of the PPs in the rectum were significantly higher than those of the sigmoid colon ($p < 0.05$, Figure 3).

4.2. Electromechanical activity

Fast activity spikes or action potentials (APs) followed the PPs both in the sigmoid and the rectum (Figures 1,2). They occurred as multiple negative deflections. They did not follow each PP and were inconsistent in a given individual subject when the test was repeated on the same or a different day. However, the APs were similarly recorded by the 2 electrodes in the same session. Their occurrence was more frequent in the rectum than in the sigmoid colon. In the latter, there were periods of long PP activity without recording the APs.

The resting pressure in the sigmoid colon varied from 4 to 11 cm H_2O (mean 8.8 ± 2.6 SD cm H_2O) and in the rectum from 6 to 13 cm H_2O (mean 9.6 ± 2.8 SD cm H_2O). The pressure increased simultaneously with bursts of the APs and not with PPs (Figure 4). The mean pressure was 30.6 ± 5.4 SD cm H_2O (range from 25 to 38 cm H_2O) in the sigmoid colon and 24.8 ± 5.3 SD cm H_2O (range from 19 to 30 cm H_2O) in the rectum.

4.3. Response of the electromechanical activity of the sigmoid colon and rectum to balloon distention

Balloon distention of the sigmoid colon enhanced the frequency, amplitude and velocity of conduction of both the PPs and the APs from the electrode proximal to the balloon, and led to a decrease in these variables from the distal electrode (Figure 5).

These changes were augmented proximal and distal to the balloon upon increasing the balloon distention and were associated with movement of the balloon down the sigmoid colon. The pressure of the sigmoid colon increased synchronously with the occurrence of APs but not with that of PPs. Upon

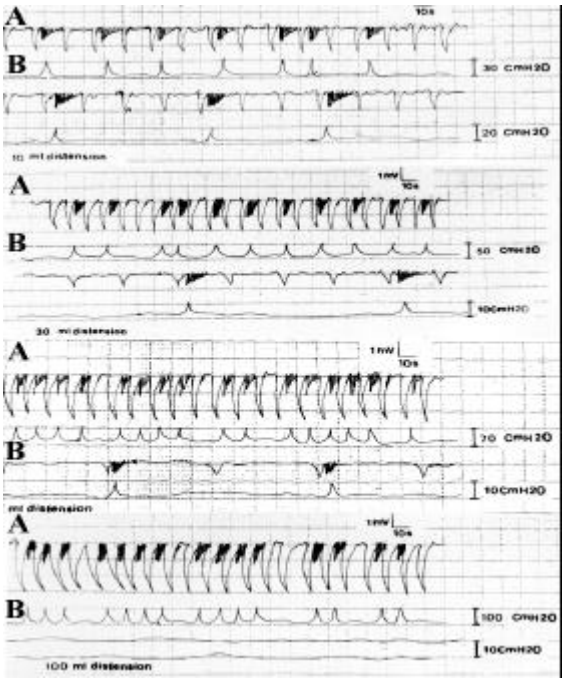

Figure 6. Simultaneous recordings of the electric activity and pressure of rectum upon balloon distention with 10 (A), 30 (B), 50 (C) and 100 (D) ml of water. There was a progressive increase of the frequency and amplitude of PPs and APs from the electrode proximal to the balloon (a) and a decrease in these variables from the distal electrode (b) until at 100 ml the distal electric activity disappeared. The APs were associated with elevation of pressure of the rectum.

increasing balloon distention the electric activity continued to increase proximally to the balloon and decreased distally. However, at a balloon distention of 80 ml, the distal electric activity disappeared and the balloon was expelled to the rectum. The intrasigmoid pressure proximally to the balloon just before balloon migration to the rectum recorded a mean of 66.2 ± 8.5 SD cm H_2O (range from 55 to 73 cm H_2O) and distally 9.2 ± 2.8 cm H_2O (range from 5 to 13 cm H_2O).

The electromechanical activity of the rectum during balloon distention of the sigmoid colon showed no significant change ($p > 0.05$) from its resting activity. When the 80 ml-distended balloon was prevented from migration to the rectum by grasping the proximal end of the catheter as it protruded from the colostomy, the resting rectal electromechanical activity was unchanged. As the distended balloon reached the rectum, the rectal PPs, APs and pressure showed a sharp increase. The rectal pressure recorded a mean of 112.8 ± 18.6 SD cm H_2O (range from 86 to 128 cm H_2O) when the balloon was expelled.

Balloon distention of the rectum did not change the electric or pressure activities of the sigmoid colon. However, it increased the rectal PPs and APs proximal to the balloon, and decreased of the rectal PPs and APs distal to the balloon. The APs were associated with elevation of rectal pressure. The changes in the electromechanical activity continued until the balloon was filled with 100 ml of water. At such point the balloon was expelled (Figure 6).

The results were reproducible when repeated in the same individual subject and showed insignificant differences ($p > 0.05$).

The fact that the shape, frequency, amplitude and velocity of conduction of the electric waves differed in the electrosigmoidogram (ESG) from those in the electrorectogram (ERG) suggests that the rectal electromechanical activity is not a continuation of the sigmoid colon activity and seems to be initiated in the rectum. Previous studies have shown that the rectal motility may be regulated by a “pacemaker” at the rectosigmoid junction (23,24).

The increased intra-sigmoid and rectal pressures associated with APs indicates that they possess contractile activity which continued to increase with increasing balloon distention until, at a certain volume, the balloon is dispelled outside the sigmoid colon or rectum. While APs were accompanied with episodes of elevated pressures in the rectum and sigmoid colon representing contractile activity, the PPs were not associated with such increases. PPs may have no role in the motile activities of these organs. In recent studies, it was suggested that the PPs seem to pace the contractile activity of the gut both in terms of direction and frequency (14,15).

4.4. Motility of sigmoid colon and rectum

The sigmoid colon receives the stools from the colon by the mass action (2,11). The new contents distends the sigmoid colon and augments its electromechanical activity. The latter increases with growing accumulation of sigmoid contents until the stools are expelled to the rectum. The movements of the sigmoid colon appear to be of the “mass type”. The current study showed that the proximal contraction of the sigmoid colon and its relaxation distal to the simulated stool occurred synchronously in one mass action and not segmentally. This mechanism pushes the contents of the sigmoid colon en masse to the rectum. The present results showed also that the distention of the sigmoid colon did not affect the electromechanical activity of the rectum. Therefore, the mass action of the sigmoid colon is independent from the colonic mass action. This is evidenced by the presence of electromechanical activity in the sigmoid colon at rest and augmented by distention of the sigmoid colon despite the sigmoid colon was disconnected from the colon by the colostomy.

The current study as well as a previous study (25) suggest that the content of the rectum is moved by a process of mass action. The passage of the fecal mass from the sigmoid colon to the rectum suddenly distends the rectum and enhances its electromechanical activity proximally to the mass and decreases it distally. This action triggers the rectal detrusor “en masse” and not

segmentally and is associated with relaxation of the internal sphincter induced by the recto-anal inhibitory reflex.

The electromechanical activity of the sigmoid colon differed from that of the rectum in terms of frequency, amplitude and velocity of conduction of the PPs and APs. This would indicate that these activities are independent and are probably triggered by different pacemakers. Furthermore, distention of sigmoid colon did not influence the electromechanical activity of the rectum and vice versa.

5. ACKNOWLEDGMENT

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