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ELECTRIC ACTIVITY OF THE RECTOSIGMOID CANAL AND ITS RELATION TO RECTAL AND SIGMOID ELECTRIC ACTIVITY: AN EVIDENCE OF A SPHINCTERIC FUNCTION OF THE RECTOSIGMOID CANAL

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1. ABSTRACT

We have previously demonstrated that the rectosigmoid junction is more than a junction: it is a segment with a mean length of 2.8 cm which we termed the 'rectosigmoid canal' (RSC). Our data support the existence of a physiologic and anatomic sphincter at the RSC which regulates the passage of stools from the sigmoid colon (SC) to the rectum (R). In view of its sphincteric action we investigated the hypothesis that the RSC has a higher electric activity than that of the SC and R. The tests were performed during repair of huge incisional hernia in 11 subjects (age 46.7±12.5 years; 8 women). The electric activity was recorded by means of 2 monopolar electrodes applied to each of the SC, RSC and R. The RSC was then anesthetized with xylocaine and the electric activity of SC, RSC and R was recorded after 10 minutes and one hour. The test was repeated using saline instead of xylocaine. The SC, RSC and R exhibited electric activity in the form of pacesetter potentials (PPs) and action potentials (APs). The PPs were monophasic in the SC and triphasic in the RSC and R. The frequency, amplitude and conduction velocity of the waves recorded from the RSC and R had higher readings ($p<0.05$) than those from the SC. The RSC and R showed a similar frequency and conduction velocity, but the RSC had a higher amplitude ($p<0.05$). Ten minutes after RSC anesthetization, electric waves were recorded from the SC but not from the RSC or R; electric activity returned one hour after anesthetization. Saline injection of the RSC did not affect the electric activity of the RSC, SC or R. The electric wave pattern and parameters of the RSC and R differed from those of the SC, suggesting that they are evoked by 2 different pacemakers. The similarity in pattern, frequency and conduction velocity of electric waves of RSC and R supposedly denotes that the rectal waves are a continuation of those of the RSC and that both are evoked by a single pacemaker located in the RSC. The higher amplitude of the RSC waves may be due to the thicker RSC musculosa in comparison to that of the SC and R and may by itself be an evidence of the sphincteric function of the RSC.

2. INTRODUCTION

The presence of a sphincter at the RSC has since long been a matter of controversy. The concept of a rectosigmoid sphincter was initially proposed by O'Beirne and later supported by Mayo (1), while other investigators denied the existence of such a sphincter (2). Our recent studies have demonstrated that the RSJ, beside being a junction, is an area with a mean length of 2.8 cm in the adult and 0.7 cm in neonates (3); we designated it the 'rectosigmoid canal' (RSC). The pressure in the RSC is higher than that in the sigmoid colon (SC) and rectum (R) (4-6). In addition, its response by relaxation or contraction upon SC and R contraction, respectively, suggested the presence of a 'physiological sphincter' (4,5).

The SC stores stools until they reach a certain volume which distends the SC and stimulates the mechanoreceptors that evoke the sigmoidorectal junction inhibitory reflex (4). The latter effects SC contraction and a decrease in RSC pressure with a resulting movement of the SC contents to the R. During passage of the fecal matter to the R, the RSC becomes distended; this initiates another reflex: the rectosigmoid-rectal reflex which causes rectal contraction (5). Rectal contraction

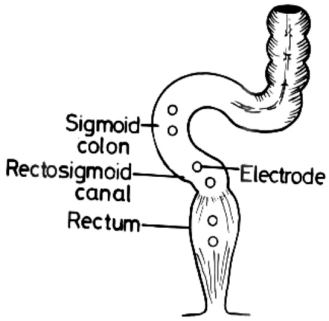

Figure 1. Sites of electrodes on the sigmoid colon, rectosigmoid canal and rectum

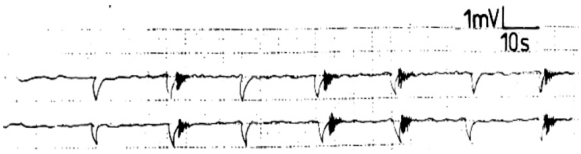

Figure 2. Electric activity recorded from the sigmoid colon showing monophasic pacesetter potentials followed randomly by action potentials

produces internal anal sphincter relaxation via the rectoanal inhibitory reflex (7,8) and results in passage of the stools to the exterior.

More recent anatomical, histological and radiological studies strongly suggest the presence of an anatomical sphincter at the RSC (3). The above mentioned data support the existence at the RSC of a physiologic and anatomic sphincter which seems to regulate the passage of stools from the SC to the R. Moreover, the presence of such a sphincter would answer the question why the left colon contents, pushed by mass contraction, stop short of the RSJ and do not pass to the R.

To further support the current data suggesting the presence of a sphincter at the RSC, we hypothesized that the RSC has an electric activity greater than that of the SC and R. This hypothesis was tested in the current communication.

3. MATERIAL AND METHODS

3.1. Subjects

The study comprised 11 subjects with a mean age of 46.7±12.5 SD years (range 35 to 54). Eight were women and 3 men. They provided an informed consent before entering the study. We selected those patients who were due for operative repair of huge incisional hernia which had occurred after cesarean section in the eight women and after laparotomy for peritonitis resulting from perforated appendix in the 3 men. The patients had had no gastrointestinal complaint in the past or at the time of enrolment. Laboratory work as well as barium enema studies were normal. Our Faculty Review Board and Ethics Committee approved the study.

3.2. Methods

The tests were performed during repair of the incisional hernia. All the patients were operated under general anesthesia. At operation, the SC, RSC and R were normally exposed through the wound and their electric activity was recorded by means of 2 monopolar silver-silver chloride electrodes (Smith Kline Beckman, Los Angeles, CA) applied to each site. Each electrode had a diameter of 0.8 mm and was covered by an insulating vinyl sheath sparing its tip. The electrodes were serially fixed by electrode gel to the serosa of the lower part of the SC, RSC and upper part of the R (figure 1). The 2 electrodes at each site were separated by a distance of approximately 2 cm. The electrodes were attached to a metal cannula containing a 6-pin socket. The insulated wire leads were attached to the sockets in the cannula and connected to a Brush Mark 200 rectilinear pen recorder. The electric activity including the frequency, amplitude and velocity of conduction of the waves was recorded from the 6 electrodes.

3.3. Rectosigmoid canal anesthetization

This test was done in only 5/11 patients who consented to it. Ten ml of 2% xylocaine (Astra, Södertälje, Sweden) were mixed with 10 ml of normal saline and injected into the wall of the RSC at multiple points. The electric activity of the RSC, R and SC was recorded after 10 minutes and then after one hour when the anesthetic effect had waned. We then injected normal saline into the RSC wall instead of xylocaine and repeated the test.

To ensure reproducibility of the results, the recordings were repeated at least twice in the individual subject. The results were analyzed statistically using the Student's t test. Values were given as the mean ± standard deviation (SD), and significance was ascribed to $p<0.05$.

4. RESULTS AND DISCUSSION

The tests were completed in all the patients with no adverse effects during or after the operation.

Electric waves were recorded from the 6 electrodes. Slow waves or pacesetter potentials (PPs) were registered from the SC; they were monophasic with a large negative deflection (figure 2). The PPs of the RSC and R were triphasic with a small positive, large negative and another small positive deflection (figure 3). The frequency, amplitude and conduction velocity of the PPs recorded from the SC, RSJ and R are exhibited in table 1. All three of the variables had significantly higher readings in the RSC and R than those in the SC. We found also that the frequency and conduction velocity of PPs were similar in both the RSC and R ($p>0.05$, $p>0.05$, respectively; table1), while the amplitude of the PPs was significantly higher in the RSC than that in the R ($p<0.05$; table 1). The PPs had a regular rhythm with identical frequency, amplitude and conduction velocity when recorded from the 2 electrodes of each of the SC, RSC and R, respectively.

The PPs were followed by fast activity spikes or action potentials (APs) which were recorded from the 6 electrodes as multiple negative deflections (figures2, 3). They occurred randomly and did not follow each PP. They had, however, similar frequencies when recorded from the 2 electrodes of each of the SC, RSC and R (figures 2, 3). The AP frequency from the RSC was greater than that from

Table 1. The frequency, amplitude and conduction velocity of the pacesetter potentials recorded from the sigmoid colon, RSC and rectum+

	Frequency (cycle / min)		Amplitude (mV)		Conduction velocity (cm / sec)	
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**
Sigmoid colon	3.4 ± 1.1	3-4	0.8 ± 0.2	0.7-1.1	3.7 ± 0.8	3.1-4.2
RSC	4.2 ± 1.3	3-6	2.3 ± 1.2	1.8-3.2	4.8 ±1.1	3.6-5.7
Rectum	4.2 ± 1.3	3-6	1.4 ± 0.6	0.9-1.7	4.8 ± 1.1	3.6-5.7

+ Values were given as the mean ± standard deviation (SD).

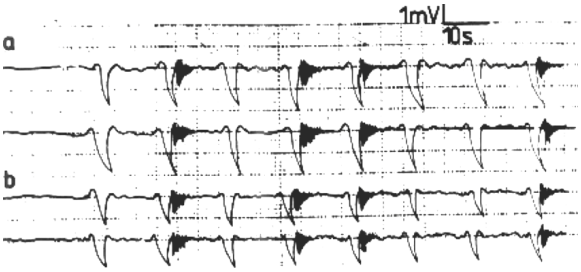

Figure 3. Electric activity recorded from a) rectosigmoid canal showing triphasic pacesetter potentials followed randomly by action potentials and b) rectum of the same subject showing triphasic pacesetter potentials followed randomly by action potentials of the same frequency and conduction velocity but of a lower amplitude than that of the rectosigmoid canal.

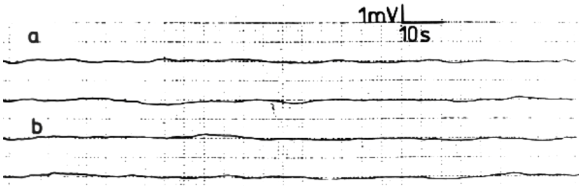

Figure 4. Electrogram from a) RSC and b) rectum of the same subject 10 minutes after RSC anesthetization. No waves were recorded.

the SC (figures 2, 3), but it was the same as that recorded from the R (figure 3).

4.1. Rectosigmoid canal anesthetization

Ten minutes after RSC anesthetization, electric waves were not recorded from either the RSC or the R, while they could be registered from the SC (figures 4, 5). The electric waves of the SC had the same characteristics as those registered before RSC anesthetization. One hour after anesthetization, the electric waves recorded from the R, RSC and SC were similar to those before anesthetization with no significant difference ($p>0.05$). When we injected saline instead of xylocaine into the RSC, we obtained recordings of the electric activity similar to those before saline injection ($p>0.05$).

The aforementioned recordings were reproducible with no significant difference when the tests were repeated in the same subject.

The current study may shed some light on the functional activity of the RSC. The RSC possesses electric activity in the form of PPs and APs. The APs are consistently coupled with elevated gut pressure (9-12). They thus appear to be responsible for the tone and contractile activity of the gut. Meanwhile the function of the PPs is not known (13-16); we believe that they pace the APs in frequency and direction (11).

The increased resting electric activity of the RSC compared to that of the R and SC seems to indicate an increased motor activity. Meanwhile, the PPs of the RSC differ from those of the SC, but are similar to those of the R. The PPs were monophasic in the SC but triphasic in the RSC and R. We do not know the significance of the difference between the RSC, SC and R wave patterns. However, the similarity between the rectal and RSC waves in pattern as well as frequency and conduction velocity suggests that the rectal electric activity is a continuation of that of the RSC. The higher amplitude of the RSC waves compared to that of the R presumably denotes an increased tonic activity of the RSC, due probably to its sphincteric character. On the other hand the difference in wave pattern and parameters of waves discharged from RSC and SC suggests a discontinuity of the electric activity between the 2 relevant gut segments and thus the existence of 2 different pacemakers.

The continuation of the RSC electric activity with that of the R might support the concept of the rectosigmoid pacemaker evoking and pacing the rectal electric activity. Previous studies have suggested the presence of a pacemaker at the RSC which discharges aboral electric waves to the rectum (17-20). Evidence in favor of the RSC being the site of a pacemaker which evokes and aborally paces the rectal electric activity, could be gathered from the current and previous studies (17-20). The similarity of the wave pattern, frequency and conduction velocity between those of the RSC and R as well as the previously demonstrated (11) aboral direction of the waves would suggest that the electric activity starts in the RSC and is continuous into the R. This concept is supported in the current study by anesthetization of the RSC which led to disappearance of the electric activity of both the RSC and R while that of the SC remained unchanged.

It may be argued that, although the electric waves of the R were similar to those of the RSC in pattern, frequency and conduction velocity, the RSC waves had a higher amplitude. We believe that this difference in wave amplitude may be related to the different histomorphologic structure of the R and RSC. Recent studies have shown that the RSC acts as a sphincter both anatomically and physiologically (3-5). The musculosa of the RSC, especially of the circular muscle layer, was thicker than the rectal one. Furthermore, RSC response by relaxation or contraction upon SC or R contraction, respectively, postulates a physiologic function of the RSC (4). Accordingly, the high

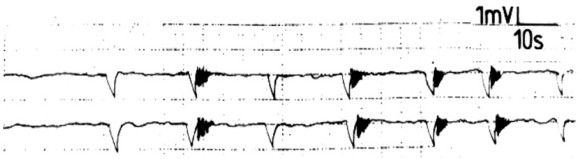

Figure 5. Electrogram from the sigmoid colon of the same subject in figure 4, 10 minutes after RSC anesthetization. Pacesetter and action potentials were recorded.

amplitude of the electric waves of the RSC as compared to that of the R waves might be due to, and by itself be an evidence of, the sphincteric function of the RSC.

In conclusion, both the RSC and R possess an electric activity with parameters higher than those of the SC indicating that the waves are assumedly evoked by 2 different pacemakers. Meanwhile the frequency and conduction velocity of the RSC electric waves were similar to those of the rectum, which would suggest that the rectal waves are a continuation of those of the RSC and that they are evoked by a pacemaker in the RSC. The higher amplitude of the RSC waves compared to that of the SC and R waves might be due to the thicker musculosa of the RSC and, by itself, may be an evidence of the sphincteric function of the RSC.

5. ACKNOWLEDGMENT

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