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ROLE OF RECTOSIGMOID JUNCTION IN FECAL CONTINENCE: AN EXPERIMENTAL STUDY

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1. ABSTRACT

To investigate the reason why, during a mass contraction, the stool moving from the colon to the sigmoid colon stops short of the rectosigmoid junction (RSJ) instead of passing directly to the rectum, and whether the sigmoid colon and RSJ share in the anorectal continent mechanism, 12 mongrel dogs were studied. Under anesthesia, the anorectum was excised, sigmoid colon and RSJ were mobilized and the caudal end was anastomosed to the perianal skin within the external anal sphincter. The pressures in the sigmoid colon, RSJ, rectum and rectal neck were measured before anorectal excision. After excision, the pressure was registered in the neorectum (sigmoid colon) and the RSJ. The external anal sphincter EMG was recorded and the balloon expulsion test performed before and after anorectal excision and after anesthetization of the neorectum. Balloon distension of the sigmoid colon to a mean volume of 46.6±7.6 ml raised the pressure in the sigmoid colon ($p<0.001$) and decreased it in the RSJ ($p<0.05$) and the balloon was dispelled to the rectum; no change occurred in the external anal sphincter EMG activity. Neorectal balloon distension to a mean volume of 62.3 ± 8.2 ml effected a pressure rise in the neorectum ($p<0.001$) and a momentary increase in the external anal sphincter EMG activity, followed by a decrease of the RSJ pressure ($p<0.05$); the balloon was dispelled to the exterior. Balloon distension of the anesthetized neorectum effected no significant changes in neorectum and RSJ pressures or external anal sphincter EMG activity. In conclusion, it is assumed that the stools arriving from the colon are halted at the RSJ by the existing high-pressure-zone and the presence of a potential sphincter at the RSJ. We suggest that fecal continence occurs at 2 levels**:** an involuntary one at the RSJ and a voluntary one at the rectal neck.

2. INTRODUCTION

The rectosigmoid junction (RSJ) is the part of the gut which links the sigmoid colon with the rectum (1,2). This area is not a mere junction but a segment which varies in length from 3.5 to 4.5 cm (mean length: 3.8 ± 0.7) (3). The sigmoid colon is considered a site of fecal storage (4); upon contraction, it delivers the stools to the rectum. As the rectum receives the feces, the recto-anal inhibitory reflex is evoked with a resulting rectal contraction, relaxation of the internal anal sphincter and stool evacuation (5,6). The sigmoid colon and the rectum are embryologically parts of the hindgut and thus have the same origin (2). However, they differ functionally. While the sigmoid colon is known as a storage organ, there is controversy regarding the function of the rectum. It is thought that the rectum functions as a conduit (1,2). A recent study has revealed, however, that the rectum might act as a fecal reservoir, especially so when the desire to defecate is neglected or aborted if circumstances for defecation are inopportune (7).

There is also debate concerning the presence of a sphincter at the RSJ. The existence of the sphincter was initially suggested by O'Beirne (8) and Mayo (9), while other investigators failed to detect it (10). Recent studies could show the presence of a high-pressure-zone at the RSJ (3,11). It was further demonstrated that the RSJ, upon sigmoid contraction, opens reflexly through the "rectosigmoid inhibitory reflex" and closes upon rectal contraction by the "rectosigmoid excitatory reflex" (3,11). The former reflex allows the feces stored in the sigmoid colon to pass to the rectum, and the latter prevents stool reflux to the sigmoid upon rectal contraction (3). These findings suggest that the RSJ might act as a functional sphincter. In spite of the findings obtained in the above studies, still some questions require an answer. Firstly, why does the stool, as it is pushed by a colonic mass contraction from the colon to the sigmoid colon, stop short of the RSJ instead of proceeding directly to the rectum, thus leaving it empty? Secondly, is the RSJ responsible for, or has a role in, the anorectal continent mechanism? Or is continence a function restricted to the anal sphincters? Can perhaps either of the RSJ and anal sphincters produce continence separately at different levels? The current study tries to answer these questions.

3. MATERIAL AND METHODS

The study was carried out on 12 mongrel dogs with a mean weight of 16.2 ± 2.4 SD kg (range 13-18). Seven were male and 5 female. The animals were housed in cages and treated in compliance with the Guide for Care and Use of Laboratory Animals (12). The internal Review Board and Ethics Committee of this institution approved the study.

3.1. Methods

Before induction of anesthesia, the animals were sedated with intramuscular injection of an atropine / acepromazine / ketamine mixture. After endotracheal intubation, they were allowed to breathe spontaneously, and anesthesia was maintained with 5% halothane – 95% oxygen by inhalation.

With the animal lying supine, the abdomen was opened through a midline incision and the sigmoid colon and rectum were exposed. The rectum was mobilized down to the levator ani using the same technique as in the abdominal part of the abdominoperineal excision operation for rectal cancer (13). It was then divided circumferentially at the level of 1.5-2 cm caudad to the RSJ. The descending and the sigmoid colon were mobilized so as to bring the sigmoid colon down into the pelvis to be ready for suturing its distal end to the perianal skin.

The dog was then put in the lithotomy position. Through a circumanal incision, the intersphincteric plane between the external and internal anal sphincters was entered and dissection extended cephalad until the already dissected lower rectum was reached. The rectum and rectal neck (anal anal) were removed. The mobilized sigmoid colon was then brought down into the pelvic cavity and its distal end was passed through the intact external anal sphincter and sutured to the perianal skin using 2/0 silk sutures. A 3rd generation cephalosporin was given intramuscularly half an hour before the operation and daily thereafter for 4 days.

3.2. Manometric studies

While the animal was under anesthesia and before the operative interference was started, pressure monitoring of sigmoid colon and RSJ was accomplished by means of a water-perfused catheter, with a metallic clip at its distal end for fluoroscopic control, which was introduced into the sigmoid colon. A second similar catheter was inserted into the rectum. The catheters were connected to strain gauge pressure transducers (Statham, 230 B, Oxnard, California, USA). The pressures in the sigmoid colon and rectum were measured. The catheter in the sigmoid colon was withdrawn by means of an automatic puller (9021, Disa, Copenhagen, Denmark) until it laid in the RSJ, and its pressure was registered. The catheter was withdrawn further to measure the rectal neck pressure. After anorectal excision and sigmoid colon mobilization to the pelvis, the manometric catheters were re-inserted: one in the neorectum (sigmoid colon) and the other in the RSJ. The catheter position was controlled fluoroscopically when it was found necessary.

3.3. EMG studies

The EMG activity of the external anal sphincter was studied by means of a concentric needle electrode (Type 13L 49, Disa, Copenhagen, Denmark), 30 mm in length and 0.45 mm in diameter. The needle electrode was introduced into the external anal sphincter 0.5 cm posterior to the anal orifice and 1 cm deep. The response of the sphincter was displayed on the oscilloscope of a standard EMG apparatus (Type MES, Medelec, Woking, UK).

3.4. Balloon expulsion test

A condom (London Rubber Industries Ltd. London, UK) mimicking accumulated stools was tied around the end of a 10F catheter which also carried a metallic clip for fluoroscopic control. The lubricated condom was introduced into the sigmoid colon and filled with saline at a temperature of 37^0C in increments of 10 ml. The pressure response of sigmoid colon and RSJ to balloon distension was recorded before and after sigmoid colon mobilization and fixation to the perianal skin.

3.5. Anesthetization of the neorectum

The neorectum was anesthetized by instillation of 15 ml of 2% xylocaine (Astra, Södertälje, Sweden) added to 15 ml of saline. Pressure responses of the neorectum and RSJ and the EMG response of the external anal sphincter to balloon distension of the neorectum were recorded 20 minutes after anesthetic instillation and 3 hours later when the anesthetic effect had disappeared.

To assure reproducibility of the results, the measurements were repeated at least twice and the mean value was calculated. The results were analyzed statistically using analysis of the variance (ANOVA). Differences assumed significance at $p<0.05$, and values were given as means ± standard deviation (SD).

4. RESULTS AND DISCUSSION

4.1. Basal pressure

The mean anal, rectal, RSJ and sigmoid pressures at rest read 69.2 ± 6.8 cm H_2O (range 62-72), 6.3±1.3 cm H_2O (range 5-8), 26.6±7.3 cm H_2O (range 21-33) and 6.5±1.2 cm H_2O (range 5-8), respectively. Balloon distension of the sigmoid colon with a mean of 46.6 ± 7.6 ml of saline (range 30-50) caused pressure rise to a mean of 53.6±7.2 cm H_2O (range 43-60, $p<0.001$) in the sigmoid colon, decline of RSJ pressure to a mean of 9.2±2.1 cm

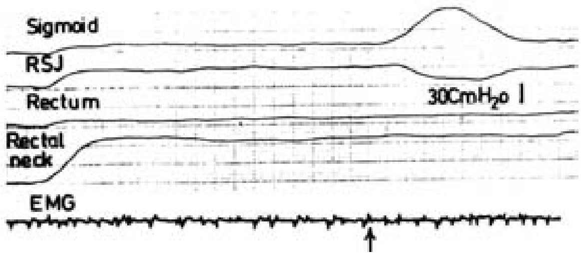

Figure 1. Pressure and EMG tracing showing the effect of balloon distension of the sigmoid colon with a mean of 46.6 ± 7.6 ml of saline on the sigmoid colon, rectosigmoid junction, rectum, rectal neck and EMG of the external anal sphincter. I = inflation

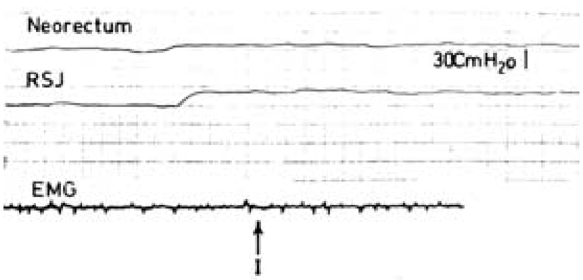

Figure 2. Pressure and EMG tracing showing the effect of balloon distension of the neorectum (sigmoid colon) with a mean volume of 53.3 ± 7.1 ml of saline on the neorectum, rectosigmoid junction, and EMG of the external anal sphincter. I = inflation.

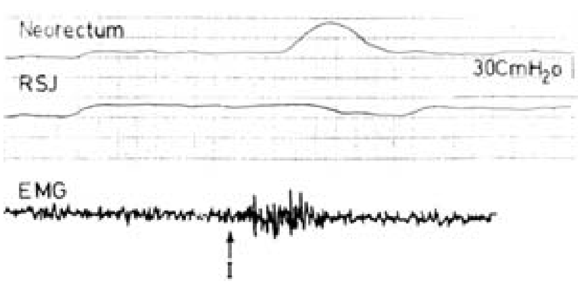

Figure 3. Pressure and EMG tracing showing the effect of balloon distension of the neorectum (sigmoid colon) with a mean volume of 62.3 ± 8.2 ml of saline on the neorectum, rectosigmoid junction, and EMG of the external anal sphincteer. I = inflation.

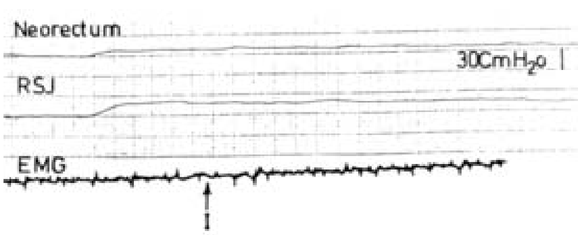

Figure 4 Pressure and EMG tracing showing the effect of balloon distension of the anesthetized neorectum (sigmoid colon) with a mean volume of 62.3 ± 8.2 of saline on the neorectum, rectosigmoid junction, and EMG of the external anal sphincte. I = inflation.

H_2O (range 7-12, $p<0.05$) and balloon expulsion to the rectum (figure 1). The anal and rectal pressures as well as the external anal sphincter EMG activity showed no significant change. Sigmoid colon distension below the aforementioned volume produced neither significant pressure changes in sigmoid colon, RSJ, rectum or rectal neck ($p>0.05$, $p>0.05$, $p>0.05$, $p>0.05$, respectively) nor a change in the EMG activity of the external anal sphincter.

4.2. Pressures after anorectal excision and mobilization of sigmoid colon and RSJ

The mean basal pressure in the neorectum (sigmoid colon) was 6.8±1.1 cm H_2O (range 6-8) and in the RSJ 25.8 ± 6.6 cm H_2O (range 21-30). Neither pressure differed significantly from that before sigmoid mobilization ($p>0.05$, $p>0.05$, respectively). Neorectal balloon distension with a mean volume below 62.3±8.2 ml (range 50-70) showed no significant changes in neorectal or RSJ pressures or in the EMG activity of the EAS (figure 2). Distension of the neorectum with a mean volume of 62.3±8.2 ml effected a significant increase in the neorectal pressure to a mean of 46.6±6.1 cm H_2O (range 35-52, $p<0.001$) and a momentary increase of the EMG activity of the external anal sphincter, followed by a decline of RSJ pressure to a mean of 7.3±1.5 cm H_2O (range 6-12, $p<0.05$) and balloon expulsion to the exterior (figure 3).

Balloon distention of the anesthetized neorectum to and above a mean volume of 62.2±8.2 ml produced no significant changes in the neorectal and RSJ pressures (figure 4) nor in the EMG activity of the external anal sphincter; the balloon was not dispelled to the exterior.

The aforementioned measurements were reproducible with no significant changes when the test was repeated in the individual animal.

The current study has demonstrated the presence of a high-pressure zone at the RSJ, similar to the one in the rectal neck except for the higher pressure in the rectal neck than in the RSJ. We hypothesize that the sigmoid colon with the RSJ resembles the rectum with the internal anal sphincter. Both organs are supplied with an involuntary smooth sphincter at their distal ends. When their contents reach a certain volume, they also both contract reflexly with a resulting momentary external anal sphincter contraction followed by relaxation of the distal sphincter or RSJ, a process mediated through the 'sigmoidorectal junction inhibitory reflex' (3) in sigmoid colon distension and through the recto-anal inhibitory reflex (5,6) in rectal distension. The momentary external anal sphincter contraction upon rectal distension is considered to be a spinal reflex (14,15). The receptors are thought to lie in the pelvic floor since the response can be elicited by colonic distension in patients with colo-anal anastomosis (16). Likewise, we believe that the external anal sphincter contraction upon neorectal distension is probably due to stimulation of extracolonic receptors.

4.3. Dual fecal control theory

The studies reported here seem to indicate that fecal continence is controlled at 2 levels: a) the RSJ and b) the anal sphincters. With the initiation of a colonic mass contraction, the stool moves to, and accumulates in, the sigmoid colon. Stool is prevented from passing directly to the rectum, presumably by the presence of a high-pressure zone at the RSJ and possibly by a physiological RSJ sphincter (3,11,17). When the fecal accumulation in the sigmoid colon reaches a certain volume, the sigmoidorectal junction inhibitory reflex is initiated with a resulting sigmoid colon contraction, RSJ relaxation and passage of the stool to the rectum (3).

We found in previous studies (3,11,17), that the volume of the balloon which distends the sigmoid colon and effects its contraction, also evokes the recto-anal inhibitory reflex which produces rectal contraction, internal anal sphincter relaxation and expulsion of the balloon to the exterior. However, if the circumstances are unsuitable for defecation, the external anal sphincter contracts and this evokes the voluntary inhibition reflex which prevents internal anal sphincter relaxation (18). Failure of the internal anal sphincter to relax leads to reflex relaxation of the rectal detrusor and waning of the desire to defecate.

In view of these results, we suggest the presence of continence mechanisms for stools at 2 different levels**:** the first one exists at the RSJ and is represented by a high-pressure zone and a potential RSJ sphincter. During a colonic mass contraction, this mechanism appears to prevent the passage of stool from the left colon directly to the rectum. It lies at the distal end of the sigmoid colon, similar to the high-pressure zone in the rectal neck at the distal end of the rectum. The sigmoid colon continence mechanism is an involuntary one; the RSJ relaxes reflexly upon sigmoid colon contraction. RSJ relaxation cannot be inhibited as the RSJ musculature is smooth and not guarded by a voluntarily acting striated muscle. The second continent mechanism exists at the distal end of the rectum and is effected by the anal sphincter. It is a voluntary mechanism. Although the internal anal sphincter relaxes reflexly upon rectal contraction (5,6), yet the relaxation can be aborted by external anal sphincter contraction (18).

The above mentioned arrangement constitutes a dual system for the control of defecation which is adaptable to circumstances. Stool continence is suggested to depend on 2 mechanisms: involuntary and voluntary. While the former seems to exert a primary involuntary fecal control at the level of the RSJ, the latter effects a final voluntary control at the level of the rectal neck. Apparently this dual continent system provides a mechanism that secures fecal control at the gut termination where stool is ready to be dispelled to the exterior.

4.4. Clinical application of the RSJ

We speculate that the sigmoid colon with the RSJ at its distal end resembles the rectum with the internal anal sphincter. Accordingly, it is suggested that in benign conditions necessitating anorectal excision the sigmoid colon with the RSJ could be mobilized and brought down to replace the anorectum. The RSJ is anastomosed to the perianal skin within the external anal sphincter. The neorectum would contract upon receiving the feces from the colon in the same manner as the rectum does. Distension of the neorectum to a certain volume would evoke the sigmoidorectal inhibitory reflex with a resulting RSJ relaxation. The momentary external anal sphincter contraction occurring upon neorectal contraction is believed to be a guarding mechanism against fecal incontinence if conditions are inopportune for defecation.

In conclusion, the fecal material arriving from the colon stops short of the RSJ due to the presence of the high-pressure-zone and a potentially existing sphincter at the RSJ. We postulate that fecal continence is provided at 2 levels**:** an involuntary one at the RSJ and a voluntary one at the rectal neck. It is thus hypothesized that, in the event of anorectal excision, the anorectum can be replaced by the mobilized sigmoid colon with the RSJ, provided the external anal sphincter has been preserved.

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