Rectal sensorimotor dysfunction in women with fecal incontinence

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Andrews C, Bharucha AE, Seide B, Zinsmeister AR. Rectal sensorimotor dysfunction in women with fecal incontinence. Am J Physiol Gastrointest Liver Physiol 292: G282–G289, 2007. First published August 31, 2006; doi:10.1152/ajpgi.00176.2006.—The rate and pattern of rectal distention affect rectal distensibility, perception, and anal relaxation in health. Because rectal urgency is a prominent symptom in fecal incontinence (FI), we assessed rectal distensibility, contractions, perception, and anal pressures during rectal distention in 21 healthy, asymptomatic women (age 61 ± 2 yr, mean ± SE) and 51 women with FI (60 ± 2 yr). Rectal staircases (0–32 mm Hg, 4-mm steps) and ramp distensions [0–200 ml at 25, 50, and 100 ml/min with a phase of sustained distension (SD), lasting 1 min, between inflation and deflation]. The rectum was stiffer during ramp than slow ramp distention. This effect was more prominent at a lower volume (50 ml) and was also more pronounced in older subjects and in FI. A rectal contractile response was observed not only during inflation but also during SD and during deflation. During inflation, this contractile response was rate dependent in controls but not in FI. During staircase but not ramp distentions, the threshold for the desire to defecate was lower in FI. During ramp distentions, the duration of perception was significantly longer in FI. The rate of distention did not affect rectal perception (i.e., sensory thresholds or duration of perception) during ramp distentions. Baseline anal pressures and the magnitude of anal relaxation during rectal distention were also reduced in FI. In addition to reduced rectal capacity and compliance, women with FI had an exaggerated rate-dependent reduction in rectal distensibility, lower sensory thresholds, and more prolonged perception, indicative of rectoanal dysfunctions.

The rate of distention is physiologically relevant because the rectum may be distended more rapidly in patients with diarrhea, overwhelming rectal accommodation and continence. The rate and pattern of rectal distention influence the rectal contractile response to distention and the perception of distention in health and in irritable bowel syndrome (IBS) (11, 25). Thus, the contractile response to rectal distention is greater during fast than slow distention (11), perhaps explaining why rapid rectal distention is more likely than slow distention to be perceived in healthy subjects and to evoke visceral hypersensitivity in IBS (11, 17, 19, 26, 27). The close temporal association between contractions and sensation also suggests that sensation may be mediated not by distention per se but by distention-induced contractions (11). The rate of rectal distention also affects anal relaxation in health. Thus, anal relaxation is more pronounced during rapid than slow rectal distention (25), suggesting that the anal sphincters can maintain continence for a longer time when the rectum is filled slowly rather than rapidly.

In this study, we compared the effect of rectal distention at different rates on rectal pressure-volume relationships, the contractile response to distention, anal relaxation, and perception in women with FI and in asymptomatic women.

METHODS

Participants

Between June 2000 and February 2003, 51 unsellected female patients (age 60 ± 2 yr; mean ± SE) with FI and 21 healthy asymptomatic women (age 61 ± 2 yr) consented to participate in this study, which was approved by the Institutional Review Board of the Mayo Clinic. A clinical interview and physical examination were performed in all participants. Healthy controls were recruited by public advertisement and were free of significant cardiovascular, respiratory, neurological, psychiatric or endocrine disease, and IBS as assessed by a validated bowel disease questionnaire (4). The severity of FI was characterized as mild, moderate, or severe by a 4-point validated scoring system (6). The use of medications (with the exception of oral contraceptives or thyroid supplementation), abdominal surgery (other than appendectomy, cholecystectomy, or hysterectomy), anorectal surgery including hemorrhoid procedures, and anorectal trauma during delivery (i.e., grade 3 or 4 laceration) as documented by obstetric records were exclusion criteria. All patients underwent an endoanal MRI to characterize the appearance of the internal and external sphincters. The results of the endoanal MRI have been previously published and will be summarized here (3).

Experimental Design

Procedures. Thirty minutes after two magnesium citrate enemas (Fleets, Lynchburg, VA) were administered, rectal compliance and...
sensation were recorded by a barostat-manometric assembly comprising an “infinitely” compliant 7-cm-long balloon with a maximum volume of 500 ml (Hefty Baggies, Mobil Chemical, Pittsford, NY) linked to an electronic rigid piston barostat (Mayo Clinic, Rochester, MN) as previously described (3, 5). During rectal distention, anal pressures were measured by four low-compliance water-perfused transducers integrated with the barostat tubing, located at 5-mm intervals and offset by 45° on the longitudinal axis. The transducers were connected to a pneumohydraulic manometric perfusion system (Arndorfer Medical Specialties, Greendale, WI) and analyzed by a computerized software program (Mayo Clinic).

After a conditioning distension (13), rectal pressure-volume relationships and sensory thresholds (i.e., first sensation, desire to defecate, and urgency) were assessed during staircase distension and deflation (0–32 mmHg in 4-mmHg steps at 1-min intervals) and during ramp distensions from 0 to 200 ml at 25, 50, and 100 ml/min in randomized order. The rectum was distended at the maximum volume (i.e., 200 ml) for 1 min between inflation and deflation. Subjects were asked to press a sensory event marker when they initially perceived the specified sensation and to keep the marker pressed for as long as they perceived the sensation. During the assessment of sensation, verbal interaction between the subject and investigator was kept to a minimum. The results of staircase distensions (i.e., pressure-volume relationships and sensory thresholds) have been presented previously (3) and will not be repeated here.

Data analysis. A single investigator reviewed all tracings to identify and exclude artifacts related to movement or straining from further analysis. Thereafter, rectal distensibility was summarized by measuring the balloon pressure at a low volume (i.e., 50 ml), at an intermediate volume (i.e., 100 ml), and at the maximum volume (i.e., 200 ml). The data for sensory thresholds that were not recorded were imputed using a “censored” data approach as described previously (3). When the first sensation threshold was not perceived, this threshold pressure was imputed using the perceived threshold for the desire to defecate or urgency, whichever came earlier. The threshold for the desire to defecate was imputed using the urgency threshold or the highest pressure during the pressure-volume curve, whichever came first. Rectal contractions were identified from the barostat pressure recording by a peak-finding program (Mayo Clinic) that relied on previously described criteria (11), i.e., monophasic increases in rectal balloon pressure that were ≥2 mmHg in amplitude above the baseline pressure, lasted for ≥5 s, and interrupted respiratory pressure fluctuations (Fig. 1). Baseline pressure was measured by averaging respiratory pressure fluctuations over consecutive 1-min epochs. The peak height of a contraction was calculated by averaging the three highest pixels within a peak. The amplitude of a contraction was the vertical distance between the baseline and the peak height. The frequency of contractions was assessed separately for all three epochs during ramp distension (i.e., inflation, sustained distension, and deflation). In addition to sensory thresholds, the duration of sensations (i.e., desire to defecate or urgency) were assessed separately for all three epochs (i.e., inflation, sustained distension, and deflation).

Immediately prior to the rectal barostat study, each patient had a dedicated anal manometry study performed using the station pull-through technique (as described in Ref. 5). During the rectal barostat study, the pressures recorded by the manometric sensor that most closely approximated the anal resting pressure measured during anal manometry (not shown) were used for further analysis. Thereafter, anal pressures were summarized for 5-min epochs (i.e., before, during, and after ramp distensions).

Statistical Analysis

Technical problems prevented an assessment of sensory thresholds in one patient with FI. Thereafter, the effect of distention rate on the following parameters was assessed by repeated-measures ANOVA using a separate analysis for each parameter: 1) balloon pressures at early (i.e., 50 ml), intermediate (i.e., 100 ml), and maximum (i.e., 200 ml) volumes during ramp distensions; 2) frequency of contractions (per minute) during each phase (i.e., inflation, sustained distension, and deflation) of ramp distensions; 3) duration of sensation (because the distribution of sensory duration was skewed, these data were analyzed after rank transformation); and 4) anal pressure during ramp distensions. Unless specified otherwise, all data are presented as means ± SE.

For each distention rate (i.e., 25, 50, and 100 ml/min), proportional hazard regression models assessed the association between sensation threshold for the desire to defecate and group status separately for pressure and volume thresholds. These models incorporated age, hysterectomy status, the pressure corresponding to half-maximum volume (Prhalf) during the compliance curve for rectal compliance, and the rectal capacity (3). Because age and hysterectomy can affect anorectal sensorimotor functions, these variables as well as subject status (i.e., control or FI) and the distention rate were included as covariates in all analyses; potential interactions between these covariates were also assessed. For these analyses, age was incorporated either as a continuous or dichotomous variable (i.e., less than or greater than the median age (60 yr) of subjects participating in this study).

The effect of distention type (i.e., ramp vs. staircase distention) and distention rate on the threshold for the desire to defecate was evaluated by proportional hazard regression models, which compared this threshold during 1) stepwise versus ramp distentions, separately at 25, 50, and 100 ml/min, and 2) among ramp distentions at 25, 50, and 100 ml/min after adjusting for subject status and hysterectomy.

Three analyses were used to assess the relationship between rectal contractions and sensation. First, the temporal relationship between contractions and sensations was assessed by defining sensations occurring within a time window beginning at the midpoint of a contraction interval and ending at 10 s after the end of the contraction interval as being associated with that contraction. The proportion of contractions that overlapped (i.e., were associated) with a sensation (desire to defecate or urgency) was calculated for each subject separately during each of their distinct infection rate periods. A repeated-measures ANOVA was used to assess whether the proportional overlap was influenced by distention rate; age, subject status, contraction amplitude, and an interaction term (i.e., rate by subject status) were incorporated as covariates in this analysis. Second, a two-sample t-test compared differences in indexes of rectal contractility (i.e., frequency, amplitude, and duration) between FI patients with normal and FI patients with increased rectal sensitivity, as defined by a volume threshold for the desire to defecate during staircase distention lower than the 5th percentile value in healthy subjects. Third, proportional hazard regression models were used to assess the relationship between rectal contractile parameters and sensory thresholds for the desire to defecate; separate models were used for sensory thresholds during...
staircase distention and during distentions at the rates of 25, 50, and 100 ml/min. These models adjusted for rectal capacity, age, hysterectomy status, and subject status (i.e., control or FI).

RESULTS

Following a questionnaire-based evaluation of bowel symptoms, 11 (22%) patients had urge, 9 (18%) passive, and 22 (43%) had combined incontinence. Nine (18%) patients did not have symptom criteria for either urge nor passive incontinence. The severity of FI was rated as mild \((n = 3)\), moderate \((n = 43)\), or severe \((n = 5)\). The duration of FI ranged from \(<1\) yr \((n = 8)\), between 1 and 5 yr \((n = 21)\), between 5 and 20 yr \((n = 19)\), and \(\geq 20\) yr \((n = 3)\). Sixteen patients (31%) had a diagnosis of diarrhea-predominant IBS. The body mass index was comparable in FI (28.7 \pm 1.0 kg/m\(^2\)) and controls (26.5 \pm 0.9 kg/m\(^2\)). Endoanal MRI revealed normal internal and external anal sphincters in 19 patients. Seven patients had an isolated tear and/or atrophy of the internal sphincter, thirteen patients had an isolated tear and/or atrophy of the external sphincter, and twelve patients had a tear and/or atrophy involving both sphincters.

Rectal Pressure-Volume Relationships During Ramp Distentions

Representative tracings (Fig. 2) and summary data (Fig. 3) suggested that rectal pressures were higher (i.e., the rectum was stiffer) when the rectum was distended at a faster rate (i.e., staircase distention and during distentions at the rates of 25, 50, and 100 ml/min. These models adjusted for rectal capacity, age, hysterectomy status, and subject status (i.e., control or FI).
100 ml/min) and in FI than in controls. The main (i.e., overall) effect of distention rate on rectal pressure was significant at a volume of 50 ml ($P < 0.0001$) but not at a volume of 100 or 200 ml. However, the effect of distention rate on rectal distensibility was also influenced by age and subject status (i.e., control or FI). Thus, at all distending volumes, rate effects were more pronounced ($P = 0.0001$) in older subjects (i.e., age ≥60 yr, which was the median age of subjects participating in the study). Similarly, the effect of distention rate on rectal pressure was more pronounced in FI than in controls at 50 ml ($P < 0.01$) and at 200 ml ($P < 0.05$) (Figs. 2 and 3).

### Rectal Contractions During Rectal Distention

During ramp distentions, rectal contractions were observed not only during inflation but also during sustained distention and, to a lesser degree, when the rectum was deflated (Table 1 and Fig. 4). During inflation, the rectal contractile response was more pronounced during rapid distention in controls (0.46, 0.82, and 0.98 contractions/min during distention at 25, 50, and 100 ml/min, respectively) but not in FI (0.67, 0.64, and 0.65 contractions/min during distention at 25, 50, and 100 ml/min, respectively, $P$ value for group × rate interaction < 0.05; Table 1). During sustained distension ($P < 0.001$) and deflation ($P < 0.02$), this contractile response was also more prominent when the rectum was distended rapidly. However, during these epochs, the interaction between group and rate was not significant (i.e., the contractile response was similar in controls and in FI).

### Rectal Sensation

During staircase distention, pressure ($P < 0.01$) and volume thresholds ($P < 0.001$) for the desire to defecate were lower in FI (median: 12 mmHg, 93 ml) than in controls (median: 16 mmHg, 162 ml) even after adjusting for rectal compliance (i.e., $Pr_{half}$) (Table 2). During this distention, 21 women with FI (i.e., 41%) had rectal hypersensitivity, i.e., a volume threshold for the desire to defecate less than the 5th percentile value for controls. The pressure threshold for desire to defecate was higher ($P = 0.0001$) during ramp (25, 50, and 100 ml/min) than staircase distention in FI but not in controls. However, among ramp distentions, pressure (Table 2) and volume thresholds for the desire to defecate were not affected by the rate of distention [i.e., median thresholds were 190 (controls) vs. 167 ml (FI) at 25 ml/min, 188 (controls) vs. 159 ml (FI) at 50 ml/min, and 191 (controls) vs. 149 ml (FI) at 100 ml/min].

Among subjects who perceived the desire to defecate or urgency during rectal inflation, the median duration of rectal perception was longer ($P = 0.01$) in FI than in controls (Table 3). For example, the median duration for perception of the desire to defecate and/or urgency during inflation at 25 ml/min was 21 s in controls and 68 s in FI. In contrast, during sustained distention ($P = 0.11$) and deflation ($P = 0.61$), the duration of perception was not significantly different between controls and FI. Moreover, the duration of perception was not affected by the rate of distention.

### Table 1. Rectal contractions during rectal distention in controls and FI

<table>
<thead>
<tr>
<th>Distension rate, ml/min</th>
<th>Inflation</th>
<th>Sustained Distention</th>
<th>Deflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controls</td>
<td>FI</td>
<td>Controls</td>
</tr>
<tr>
<td>25</td>
<td>0.46 ± 0.13</td>
<td>0.67 ± 0.13</td>
<td>0.51 ± 0.18</td>
</tr>
<tr>
<td>50</td>
<td>0.82 ± 0.20</td>
<td>0.64 ± 0.12</td>
<td>1.45 ± 0.25</td>
</tr>
<tr>
<td>100</td>
<td>0.98 ± 0.23</td>
<td>0.65 ± 0.14</td>
<td>1.42 ± 0.38</td>
</tr>
</tbody>
</table>

Group by rate interaction $P = 0.05$ $P = NS$ $P = NS$

Values are means ± SE (in contractions/min). FI, fecal incontinence; NS, not significant.

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Fig. 4. Representative tracing showing brief increments in rectal pressure, reflecting rectal contractions (identified by arrows) during rectal ramp distention at 100 ml/min. Observe the contractions during inflation, sustained distention, and deflation.
Relationship Between Rectal Contractions and Rectal Sensation

Among controls, an overlap (i.e., temporal association) between contractions and sensation of the desire to defecate or urgency was observed during 4 ± 3% (mean ± SE) of contractions at 25 ml/min, 16 ± 8% at 50 ml/min, and 28 ± 10% at 100 ml/min. Among women with FI, an overlap was observed during 9 ± 3% of contractions at 25 ml/min, 20 ± 6% at 50 ml/min, and 12 ± 4% at 100 ml/min. The proportional overlap was not significantly related to age, subject status (i.e., controls vs. FI), contraction amplitude, or distention rate.

During ramp distentions, the contractile frequency, amplitude, and duration were greater among women with FI and rectal hypersensitivity (i.e., sensory threshold for desire to defecate <5th percentile value for controls) than among women with FI and normal rectal sensation (Table 4); these differences were not statistically significant. Proportional hazard regression models revealed that rectal capacity was associated (P < 0.01) with the threshold for the desire to defecate during staircase distention (hazard ratio: 0.99, 95% confidence interval: 0.987–0.998) and during ramp distentions (data not shown) at all three rates. A hazard ratio of <1 implies that this sensation was perceived later (i.e., that the sensory threshold was higher in patients with higher rectal capacity). Among the contractile parameters, the amplitude of the contractile response during ramp distention at a rate of 50 ml/min was associated (P = 0.04) with a lower sensory threshold (hazard ratio: 1.73, 95% confidence interval: 1.02–2.90) and the duration of contractions was also associated (P < 0.05) with a lower sensory threshold (hazard ratio: 1.15, 95% confidence interval: 1.00–1.32).

Anal Relaxation

Anal resting pressure was reduced in 22 patients (43%), and the squeeze increment was reduced in 32 patients (63%) with FI. Thus, average anal resting pressure (i.e., before inflation) was lower (P < 0.001) in FI (e.g., 29 mmHg before staircase distension) compared with controls (e.g., 51 mmHg before staircase inflation; Table 5 and Fig. 2). Anal relaxation during rectal staircase distentions was more pronounced (P ≤ 0.02) in controls compared with FI. During rectal ramp distention, anal relaxation was more pronounced during rapid than slow distention in controls but not in FI (group by rate interaction: P = 0.04).

DISCUSSION

Previous studies have shown that the rate and pattern of rectal distension influence the rectal contractile response, rectal perception, and anal relaxation in healthy subjects. Rectal mechanical properties can be divided into properties arising from 1) a “passive” or connective tissue element; 2) an active (“tonic”) element, reflecting baseline muscle activity; and 3) an active (“reflex contractile”) element, reflecting the effects of distension-induced neural reflexes. We documented reduced rectal capacity in 27% of women with FI and reduced rectal compliance in 23% of women with FI (3). That report was based on staircase distentions, during which the balloon pressure and volume are allowed to equilibrate at each step, providing insight into passive and tonic elements. In addition to assessing passive properties and muscle “tone,” ramp distentions, in which pressure and volume are not permitted to equilibrate during distention, also induce a reflex contractile response. In this study, we investigated the rectal mechanical properties and sensation during staircase and ramp distentions to analyze the relationship between the rectal tone, rectal contractions, and rectal perception in health and in FI.

There are five main observations in this report. First, we observed that the rectum was stiffer during rapid than slow ramp distentions; this rate dependency was more pronounced in older subjects and in FI. The rectal contractile response was

Table 3. Effect of rectal distention on duration of symptoms (i.e., desire to defecate and urgency) in controls and FI

<table>
<thead>
<tr>
<th>Distension Rate, ml/min</th>
<th>Controls (n = 21)</th>
<th>Fecal Incontinence (n = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inflation</td>
<td>Sustained Distention</td>
</tr>
<tr>
<td></td>
<td>Controls</td>
<td>FI</td>
</tr>
<tr>
<td>25</td>
<td>21 (12–42)</td>
<td>68 (33–96)*</td>
</tr>
<tr>
<td>50</td>
<td>19 (6–55)</td>
<td>56 (25–92)*</td>
</tr>
<tr>
<td>100</td>
<td>36 (17–50)</td>
<td>41 (20–70)*</td>
</tr>
</tbody>
</table>

Group by rate interaction P = NS

Values are medians (in s) with interquartile ranges in parentheses. *P = 0.01 vs. controls.
Table 4. Relationship between the rectal contractile response to distention and rectal sensation in FI

<table>
<thead>
<tr>
<th>Distention rate, ml/min</th>
<th>Normal sensation</th>
<th>Increased sensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.57±0.17</td>
<td>0.80±0.20</td>
</tr>
<tr>
<td>50</td>
<td>0.54±0.16</td>
<td>0.79±0.19</td>
</tr>
<tr>
<td>100</td>
<td>0.40±0.12</td>
<td>0.63±0.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Normal sensation</th>
<th>Increased sensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction Amplitude, mmHg</td>
<td>Contraction Duration, s</td>
</tr>
<tr>
<td>0.55±0.19</td>
<td>2.19±0.86</td>
</tr>
<tr>
<td>0.45±0.16</td>
<td>2.09±0.85</td>
</tr>
<tr>
<td>0.60±0.26</td>
<td>1.74±0.74</td>
</tr>
</tbody>
</table>

Values are means ± SE.

also more pronounced during rapid distention in controls but not in FI. Second, in contrast to rectal stiffness, the rate of distention did not affect sensory thresholds or the duration of perception in controls or in FI. Third, 40% of women with FI had rectal hypersensitivity during staircase distentions. However, during ramp distentions, rectal hypersensitivity in FI was manifest by prolonged perception rather than by lower sensory thresholds. Fourth, we observed an association between altered rectal biomechanical properties and rectal hypersensitivity in FI. Finally, rectal contractions and perception were observed not only during rectal inflation but also during sustained distention and during deflation.

The effect of distention rate on rectal distensibility during ramp distentions varied across distending volumes and was also affected by age and disease (i.e., FI). At volumes of 50 and 200 ml, the rectum was less distensible in FI than in controls. The effect of distention rate was significant at a low volume (i.e., 50 ml) but not at intermediate (i.e., 100 ml) or high (i.e., 200 ml) volumes, which is consistent with the concept that “active” properties (i.e., muscle tone and contractile response) explain a larger component of rectal distensibility at lower compared with higher distending volumes (2, 15). At all volumes, the rectum was less distensible in older than in younger subjects, confirming the results of a previous study (12) that showed that rectal stiffness increases with age even in asymptomatic subjects. Larger studies are necessary to define the age at which effects on rectal stiffness become manifest in asymptomatic women.

During staircase distentions, pressure and volume thresholds for the desire to defecate were lower in FI than in controls. However, during ramp distentions, pressure and volume thresholds were not significantly different between FI and controls. In contrast to rectal stiffness, rectal sensory thresholds were not affected by the rate of ramp distention. Corsetti et al. (11) previously showed that the rectal contractile response and perception of distention were more pronounced during distention at 100 ml/min than at 10 ml/min. We did not distend the rectum at 10 ml/min because the rectum is probably distended at a faster rate under physiological circumstances. Similarly, in the guinea pig rectum, the distention-induced contractile response and sensory thresholds were more prominent during rapid (i.e., at 5 mm/s) circumferential stretches, which were 25-fold faster than slow (i.e., at 20 μm/s) circumferential stretches (14).

Because in-series receptors respond to tension, it is conceivable that impaired rectal accommodation (i.e., manifest as reduced capacity or compliance), and/or an alteration in passive properties and/or an exaggerated contractile response to distention result in increased rectal tension, thereby contributing to increased perception in FI. Indeed, we observed that reduced rectal capacity was associated with rectal hypersensitivity during staircase distentions in FI (3). In this study, reduced rectal capacity was also associated with rectal hypersensitivity during ramp distentions in FI. Using ambulatory manometry, Chan et al. (9) demonstrated a stronger association between rectosigmoid motor activity and the urge to defecate in patients with FI and rectal hypersensitivity than in FI with normal rectal sensation or in healthy subjects. Our data also suggest a relationship between rectal hypercontractility and rectal hypersensitivity (i.e., an exaggerated contractile response to rectal distention) at a low rate (i.e., 25 ml/min). However, the link between reduced rectal capacity and rectal hypersensitivity was more consistent, i.e., during staircase and all ramp distentions. It is also conceivable that increased visceral sensitivity partly reflects a primary phenomenon, i.e., unrelated to abnormal rectal mechanical properties. While this study focused on the rectum, there is evidence to suggest that stretching of the upper anal canal or surrounding structures (e.g., the pelvic floor) may also contribute to the perception of rectal filling (8).

Rectal contractions and sensations were observed not only during inflation but also during sustained distention and during

Table 5. Anal pressures during rectal distention in controls and FI

<table>
<thead>
<tr>
<th>Staircase Distension rate, ml/min</th>
<th>Controls</th>
<th>FI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before inflation</td>
<td>During inflation</td>
</tr>
<tr>
<td>25</td>
<td>51.4±5.9</td>
<td>45.7±5.6</td>
</tr>
<tr>
<td>50</td>
<td>49.1±6.5</td>
<td>43.4±5.9</td>
</tr>
<tr>
<td>100</td>
<td>49.4±7.5</td>
<td>44.4±6.5</td>
</tr>
</tbody>
</table>

Values are means ± SE.
deflation. Moreover, in contrast to inflation, the rectal contractile response during sustained distention and deflation was more pronounced when the rectum was distended at a faster rate. Rectal contractions during deflation probably reflect post inhibitory rebound contractions, which are characteristic of many excitable cells, including intestinal circular muscle and taenia coli (28). Thus, when stretch is released, the membrane potential depolarizes beyond the resting potential to spike threshold.

The perception of distention was almost threefold longer in FI than in controls. Therefore, the duration of perception, which may correspond to the symptom of persistent urgency in FI, was more useful than sensory thresholds for discriminating between controls and FI. A combined assessment of sensory thresholds and duration of perception may overcome a potential limitation of measuring sensory thresholds alone, i.e., that they provide a limited assessment of the intensity of perception. Prolonged visceral perception may be explained by central or peripheral mechanisms. Peripheral mechanisms would entail sustained firing by extrinsic visceral afferents. Indeed, mechanosensitive afferents in pelvic nerves from the mouse colon respond to circular stretch and, in contrast to splanchnic afferents, continue to discharge for up to 60 s after the onset of distention (7). Alternatively, the rectospinal neurons that project directly from the rectum to the spinal cord in rats may also mediate prolonged visceral perception (16). However, the functions of these rectospinal neurons is unknown. The intraganglionic laminar endings described in the guinea pig rectum cannot explain prolonged perception, since they cease firing as the rectum adapts to sustained distention (14, 29).

Anal pressures were lower in women with FI. Perhaps as a consequence (i.e., because of a “floor” effect), anal relaxation during rectal distention was not more pronounced in FI (1). Moreover, anal relaxation was more pronounced during rapid distention in controls but not in FI.

In summary, these observations support the concept that FI in women is a disorder of rectoanal rather than isolated anal dysfunction (10, 20). Indeed, the comparison of rectal and anal pressures during rectal distention suggests that rectal distention, particularly by 200 ml, may be sufficient to overwhelm a weak pelvic barrier, even at rest, in elderly subjects who are continent at baseline. In addition to reduced rectal capacity and compliance (3), an exaggerated rate-dependent reduction in rectal distensibility and more prolonged perception were other manifestations of rectal sensori-motor dysfunctions. Reduced rectal capacity and, to a lesser extent, the rectal contractile response to distention were associated with and may explain rectal hypersensitivity. Further studies before and after pharmacological modulation of rectal contractility are necessary to clarify the pathophysiology of disordered rectal mechanical properties and the relationship between symptoms (i.e., rectal urgency) and rectal sensorimotor dysfunctions in FI.

REFERENCES


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