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Influence of Emotional Stimuli on Rectal Tone

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1. Abstract

1.1. Introduction

Though it is widely recognized that the motor function of the gastrointestinal tract is influenced by different psychological and emotional influences, the responses of rectal tone to emotional experiences continues to be poorly understood.

1.2. Aim

To analyse associations between the variations of the rectal tone to experimentally induced emotional stimuli.

1.3. Materials and Methods

A prospective, randomized study was carried out; a total of 20 patients were assessed using anorectal manometry. Two types of sound stimuli were used: reassuring (Canon in D major by Pachelbel) and stressful (loud baby crying). Patients were randomly divided into two groups: sequence 1 started with the reassuring stimulus and sequence 2 started with the stressful stimulus. In both groups, measurements of amplitude, duration and coefficient of rectal contractions induced by insufflation of a rectal balloon with volumes of 60 and 80 cm^3 were taken at baseline and then in response to both stimuli.

1.4. Results

The reassuring stimulus decreased the amplitude, duration and coefficient of contractions (46.09 IC ± 18.6 vs. 28.14 IC ± 15.4, $p = 0.05$). The stressful stimulus increased the amplitude, duration and coefficient of contractions (55.21 IC ± 36.6 vs 83.22 IC ± 58.8, $p = 0.04$) and this increase could not be reduced with a subsequent reassuring stimulus (28.14 IC ± 15.4 vs 94.02 IC ± 70.6, $p = 0.05$). Conclusions: We observed that the response of the rectal wall to the insufflation of a balloon is influenced by stressful and calming sonic stimuli. A stressful stimulus increases the amplitude, duration and contraction coefficient of rectal wall tone and a reassuring stimulus reduces these parameters, as long as there was no preceding stressful stimulus.

2. Introduction

The tone of the rectal wall is defined as the relationship between volume and pressure in a hollow viscus where an increase in volume represents relaxation and vice versa [1]. The tone of the rectal wall has influence over the ability to contain or expel stools, so it is one factor to be taken into account in patients with faecal incontinence or constipation due to obstructed evacuation (outlet syndrome).

The rectal tone response due to emotional experiences continues to be poorly understood. It is believed that the motor function of the gastrointestinal tract is influenced by different mental states that are determined by psychological and social factors. In patients with irritable bowel syndrome stress and psychiatric disorders have a strong impact on the symptomatology of this disease [2]. Different pathophysiological mechanisms can impact on any of the structures that are components of the gut-brain axis, which refers to the functional and bidirectional axis between the gastrointestinal tract and the central nervous system.

3. AIM

To analyse the possible association between variations of rectal tone induced by insufflation of a rectal balloon and experimentally induced emotional stimuli.

4. Materials and Methods

4.1. Study design: Prospective, Randomized Clinical Study

4.1.1. Inclusion Criteria: We included men and women over 18 years old who were referred to the Motility and Functional Studies Unit from CEMIC's Gastroenterology Section for motility studies for evaluation of faecal incontinence (FI) or constipation with symptoms of obstructed evacuation (OE). It was also determined whether they satisfied Rome IV criteria for irritable bowel syndrome (IBS) and their IBS according subtype (constipation, diarrhoea or mixed) was also defined.

4.1.2. Exclusion Criteria: Patients with any rectal anatomical abnormality due to prior surgery or a congenital disorder, any evidence of an underlying neurological or spinal cord disorder, or a cognitive disorder that would make it difficult to understand instructions.

4.1.3. Methodology: A recto-anal manometric study was performed in all cases using a perfused catheter assembly incorporating four radially arrayed side holes. Measurements of the following variables were made: anal canal basal pressure, maximum pressure of anal canal during voluntary contraction, basal rectal tone, presence and intensity of the anorectal inhibitory reflex, cough reflex, compliance of the rectal wall, amplitude, duration and coefficient (includes amplitude and duration) of the rectal contraction induced by insufflation of a balloon with volumes of 60 and 80 cm³ of air, rectal sensitivity, rectal balloon expulsion test and endoanal surface electromyography. A "Sailor" manometer, 4-channel radial catheter and 6 x 2 cm latex rectal balloon were used (Figure 1).

The diagnosis of pelvic floor dyssynergia was confirmed by using three methods: anorectal perfusion manometry, endoanal surface electromyography, and the rectal balloon expulsion test. Dyssynergia was considered when 2 of 3 studies were positive.

On the other hand, the symptomatic severity of IBS according to IBS-SSS7 and symptoms of depression, anxiety, phobic anxiety and somatization was evaluated through validated questionnaires according to the L. Derogatis Symptom inventory SCL-90-R8.

In all patients, two types of sequential aural stimuli were employed using headphones: a Reassuring sound: soft and relaxing music (Canon in D major by Johann Pachelbel) and a Stressful sound: Lound baby crying.

The assessment was carried out by measuring the amplitude in millimetres of mercury (mmHg), duration in seconds (s) and coefficient (product of amplitude and duration) of the rectal contraction induced by insufflation of a rectal balloon with increasing volumes of 60 and 80 cm³ first at baseline and then on exposure to both types of stimuli (Figure 2). Patients were randomly divided into two groups: sequence 1, those who started with reassuring stimuli and then with stressful stimuli; and sequence 2, first started with stressful stimulus and then reassuring stimulus. The randomization of both groups was performed using the Soft Pine Tools program®.

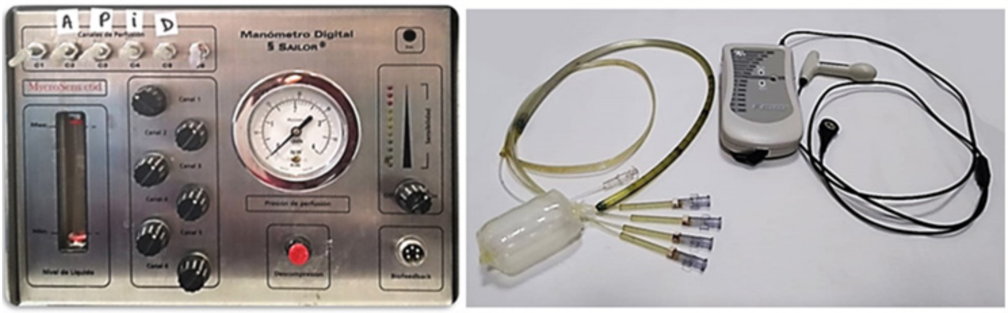

Figure 1: Instruments used: "Sailor" Manometer, 4-channel radial catheter, 6 x 2 cm latex rectal balloon and an endoanal surface electromyogram.

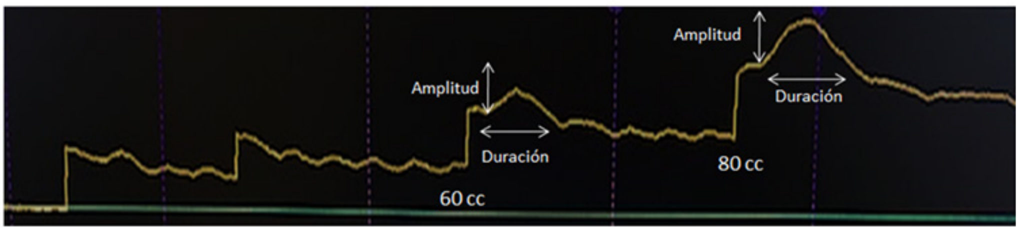

Figure 2: Manometric plot of amplitude and duration of rectal contraction induced by balloon insufflation with increasing volumes of 60 and 80 cc.

4.2. Statistical Analysis

The analysis and comparison of measurements were carried out using either parametric or non-parametric statistics, as appropriate (T-test with two tails for paired data and Chi square or Fischer's Exacg test), mean and/or median and confidence interval (CI) 95%, using Vassar stats statistical program. A P value of less than 0.05 was accepted as a significant difference. As a pilot test, a total number of 20 patients was estimated for this study, each subject acted as his/her own control.

5. Results

Twenty patients were included, randomly distributed into 2 groups: 10 subjects in sequence 1 and 10 subjects in sequence [2]. Average age was of 70.9 and 54.5 years respectively for each sequence. There were 3 men and 7 women in each group. 5 were diagnosed with OE and 5 with FI in each group. IBS was present in 5 subjects in each group. Baseline measurements of amplitude, duration and coefficient of contraction were similar in both groups at baseline (Table 1).

Table 1: Description of the studied population.

	(Sequence 1(n=10	(Sequence 2(n=10	.*p*
Age	±3.4 70.9	±7.87 54.5	*p*.<0.0002
(Gender (M:F	3:07	03:07	NS
(Reason of study(OE:FI	5:05	05:05	NS
IBS	5	5	NS
Dyssynergia	5	2	NS
Baseline amplitude	±1.6 5.41	±1.5 6.46	NS
Basaline duration	±3.2 8.36	±1.75 7.50	NS
Baseline coefficient	±37 51.36	±18.51 49.94	NS

5.1. Contraction Coefficient

The contraction coefficient in response to the reassuring stimulus was lower (28.14 CI ± 15.4) compared with the baseline coefficient (46.09 CI ± 18.6, p = 0.05). In contrast, the stressful stimulus resulted in a significant increase in the contraction coefficient (83.22 CI ± 58.8) compared with baseline (55.21 CI ± 36.6, p = 0.04).

Contraction coefficient was lower when an initial reassuring stimulus (28.14 CI ± 15.4) was used, compared with it being used after a stressful one (94.02 CI ± 70.6, p = 0.05).

5.2. Duration of Contraction

Regarding the duration of contractions, differences were even more significant. The stressful stimulus increased the duration of contractions (CI 11.24 ± 3.4) compared with baseline (8.62 ± 2.8 CI, p = 0.01).

In comparison with the reassuring stimulus (6.61 CI ± 2.3), the stressful stimulus increased the duration of contractions in sequence 1 (7.93 CI ± 2.08, p = 0.02) and also in sequence 2 (11.24 CI ± 3.4, p = 0.02).

The duration of contractions was lower during the initial reassuring stimulus (6.6 CI ± 2.3) compared with this stimulus followed by stressful stimulus (12.10 CI ± 6.5, p = 0.04).

The duration of contractions was higher when the first stimulus was stressful (11.24 CI ± 3.4) and lower when the stressful stimulus was applied after the reassuring stimulus (7.93 CI ± 2.08, p = 0.04).

5.4. Contraction Amplitude

The amplitude of contractions was lower with the reassuring stimulus (3.72 CI ± 1.39) compared with baseline amplitude (6.16 CI ± 1.46, p = 0.004).

The amplitude of contractions was lower with an initial reassuring stimulus (3.72 CI ± 1.39) than with an initial stressful stimulus (6.45 CI ± 2.81, p = 0.03).

When the reassuring stimulus was used after a stressful stimulus, the amplitude of contractions was higher (6.16 CI ± 2.34) than when the reassuring stimulus was first used (3.72 CI ± 1.39, p = 0.03).

Table 2 and Figure 3 summarize the mentioned results.

Irritable bowel syndrome and psychological profile

Patients with IBS had higher baseline measurements of amplitude and contraction coefficient (amplitude 6.94 CI ± 1.69 and coefficient 65.3 CI ± 35.1) than subjects without IBS (amplitude 4.93 CI ± 1.15, p = 0.02 and coefficient 36.0 CI ± 15.35, p = 0.05). No significant differences were observed in measurements after exposure to reassuring or stressful stimuli between patients with or without IBS (Table 3).

Paradoxically, subjects with the highest somatization score had a lower baseline contraction coefficient (32.59 CI ± 11.41 vs. 68.72 CI ± 34.80, p = 0.03). However, no significant differences were found in the baseline coefficient between subjects with more or less anxiety, phobic anxiety or depression. Neither no significant differences were found in the baseline coefficient between subjects with high or low compliance or basal resting pressure, nor relation to age, sex or reason for the study (Table 4).

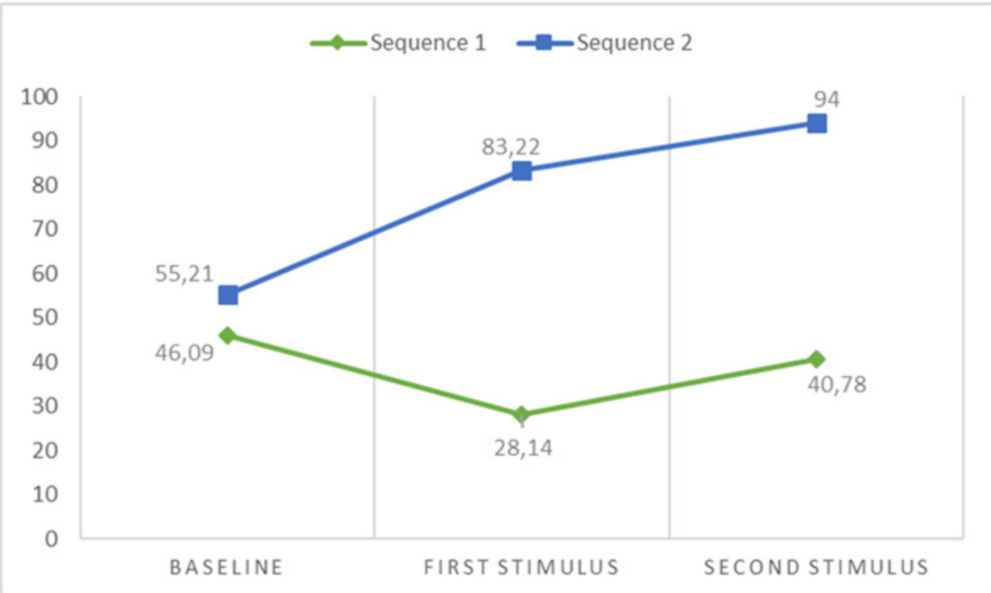

Figure 3: Effects of stimuli on the coefficient of rectal contraction. Sequence 1: first reassuring stimulus decreased contraction coefficient (p.0.05) and then stressful stimulus increased it (p.0.25). Sequence 2: first stressful stimulus increased contraction coefficient (p.0.04) and then reassuring stimulus failed to reduce this coefficient (p.0.48).

Table 2 Results: Values in bold font are those with significant differences. Response to insufflation of rectal balloon: (A) amplitude, (D) duration and (C) contraction coefficient (AxD). Baseline 1: Response without stimuli in sequence 1. Baseline 2: Response without stimuli in sequence 2. Relaxing 1: Response to reassuring stimulus in sequence 1. Relaxing 2: Response to reassuring stimulus in sequence 2. Stress 1: Response to stressful stimulus in Sequence 1. Stress 2: Response to stressful stimulus in sequence 2.

	VARIABLES	RELAXING 1	RELAXING 2	STRESS 1	STRESS 2
BASELINE 1	A	6.16 ±1.46 vs 3.72 ±1.39 (p=0.004)		6.16 ±1.46 vs 4.41 ±2.42 (p=0.04)	
	D	7.24 ±2.23 vs 6.6 ±2.3 (p=0.66)		7.24 ±2.23 vs 7.93 ±2.08 (p=0.60)	
	C	46.09 ±18.6 vs 28.14 ±15.4 (p=0.05)		46.09 ±18.6 vs 40.78 ±34.82 (p=0.69)	
BASELINE 2	A		5.71 ±1.78 vs 6.16 ±2.34 (p=0.64)		5.71 ±1.78 vs 6.45 ±2.81 (p=0.40)
	D		8.6 ±2.8 vs 12.1 ±6.5 (p=0.12)		8.62 ±2.8 vs 11.24 ±3.4 (p=0.01)
	C		55.21 ±36.60 vs 94.0 ±70.56 (p=0.13)		55.21 ±36.6 vs 83.22 ±58.8 (p=0.04)
BASELINE 1	A		3.72 ±1.39 vs 6.16 ±2.34 (p=0.03)	3.72 ±1.39 vs 4.41 ±2.42 (p=0.28)	3.72 ±1.39 vs 6.45 ±2.81 (p=0.03)
	D		6.6 ±2.3 vs 12.10 ±6.5 (p=0.04)	6.61 ±2.3 vs 7.93 ±2.08 (p=0.02)	6.6 ±2.3 vs 11.24 ±3.4 (p=0.02)
	C		28.14 ±15.4 vs 94.02 ±70.6 (p=0.05)	28.14 ±15.40 vs 40.78 ±34.80 (p=0.25)	28.14 ±15.4 vs 83.22 ±58.8 (p=0.05)
RELAXING 2	A			6.16 ±2.34 vs 4.41 ±2.42 (p=0.25)	6.16 ±2.34 vs 6.45 ±2.81 (p=0.69)
	D			12.10 ±6.5 vs 7.9 ±2.08 (p=0.18)	12.10 ±6.5 vs 11.24 ±3.4 (p=0.56)
	C			94 ±70.6 vs 40.8 ±34.8 (p=0.14)	94 ±70.5 vs 83.22 ±58.8 (p=0.48)
				±34.8 (p=0.14)	83.22 ±58.8 (p=0.48)
STRESS 1	A				4.41 ±2.42 vs 6.45 ±2.81 (p=0.23)
	D				7.93 ±2.08 vs 11.24 ±3.4 (p=0.04)
	C				40.78 ±34.8 vs 83.22 ±58.8 (p=0.17)

Table 3: Comparison of measurements in patients with and without IBS. Only the Baselines Measurements of amplitude and coefficient were significantly higher in the group with IBS.

	VARIABLES	WITH IBS	WITHOUT IBS	*p.*
BASALINE	A	6.94 ±1.69	4.93 ±1.15	0.02
	D	8.75 ±3.01	7.11 ±1.95	0.31
	C	65.3 ±35.1	36.0 ±15.35	0.05
RELAX	A	5.55 ±2.48	4.32 ±1.58	0.35
	D	9.12 ±5.07	9.59 ±5.52	0.89
	C	67.79 ±62.5	54.35 ±49.86	0.7
STRESS	A	6.69 ±3.46	4.17 ±1.08	0.13
	D	9.48 ±3.24	9.68 ±2.98	0.92
	C	79.71 ±66.07	44.29 ±21.5	0.26

Table 4: Of other variables studied, significant differences were in the baseline contraction coefficient were observed between subjects with and without pelvic floor dyssynergia (subjects with dyssynergia had a lower baseline coefficient) and high somatization index (lower baseline coefficient of contraction).

Baseline coefficient measurement					
Age (years)	>65	49.68 ±33.23	<64	51.84 ±20.58	p. 0.90
Gender	Male	37.91 ±26.16	Female	56.11 ±25.65	p. 0.36
Dyssynergia	Present	29.42 ±15.64	Absent	62.08 ±26.81	p. 0.03
Reason of study	OTS	44.10 ±16.30	IF	57.20 ±37.38	p. 0.47
Basal Pressure (mmHg)	>4.5	46.47 ±16.62	<4.5	54.83 ±37.62	p. 0.65
Compliance	>10	59.9 ±36.29	<10	41.40 ±17.24	p. 0.31
Anxiety	High	41.48 ±20.27	Low	59.82 ±34.72	p. 0.31
Depression	High	46.06 ±21.11	Low	55.24 ±35.24	p. 0.61
Somatization	High	32.59 ±11.41	Low	68.72 ±34.80	p. 0.03
Phobicanxiety	High	63.05 ±36.45	Low	38.25 ±14.44	p. 0.16

5.5. Pelvic Floor Dyssynergia

Subjects with pelvic floor dyssynergia had a lower baseline contraction coefficient (29.42 CI ± 15.64) compared with subjects without dyssynergia (62.08 CI ± 26.81, p = 0.03) (Table 4).

6. Conclusions And Discussion

We observed that stressful stimuli increased the amplitude, duration and contraction coefficients of the rectal wall and a reassuring stimulus reduced the rectal response as long as a prior stressful stimulus had not been presented.

IBS subjects presented an increased baseline response compared to subjects without IBS. However, they did not show significant differences with either stimulus. Although there were differences in rectal tone between subjects with and without IBS, emotional stimuli did not seem to produce important differences in responses between both groups.

Somewhat unexpectedly, we observed a significantly lower baseline coefficient in subjects with a higher level somatization and with pelvic floor dyssynergia. Also, Anxiety and depression did not seem to have an influence on the responses induced by emotional stimuli.

The response to insufflation of a rectal balloon, by measuring pressure within it, generates an immediate increase in the tone of the rectal wall followed by a stable pressure that is maintained until the next insufflation. This increase in the tone of the rectal wall induced by insufflation represents a reflex response that could be linked to a central nervous system control.

Blomhoff et al. [3], studied the impact of emotions on rectal tone in patients with irritable bowel syndrome divided into three groups: healthy control subjects, IBS without psychiatric pathology and IBS patients with phobic anxiety disorders. All patients were stimulated with emotional content words. It was found that the rectal tone varied in 70.3% of subjects exposed to angry words, 75% to sadness and 76.6% to anxiety. That is, words with different emotional characteristics generated a sufficient stimulus to induce changes in rectal tone [3].

It was found that patients with IBS with or without psychiatric comorbidity had a higher basal rectal tone compared with healthy controls (p <0.001). IBS patients with phobic anxiety had a tendency to present an increased rectal tone compared with patients with IBS without psychiatric comorbidity. However, no statistically significant difference was evident.

The same authors analysed electroencephalographic activity (EEGA) in the same groups exposed to a stimulus that featured words with emotional content4. A similar response pattern was observed, as the two groups with IBS had a higher EEGA amplitude wave in the frontal lobe area (representing the sensory process and attention) in comparison with the control group. Therefore, the increase of rectal tone observed in patients with IBS with or without psychiatric comorbidity could be caused by increased attention due to stress and anxiety experienced through aural stimuli.

The bidirectional nature of the gut-brain axis was demonstrated by Aizawa et al. [5], when studying the effect of transcranial magnetic stimulation on rectal function5. In recent years, numerous functional studies with neuroimaging have linked the prefrontal cortex with visceral nociception and its activation has been associated with emotional states such as anxiety.

The hypothalamic-pituitary-adrenal axis has also been studied in patients with IBS, where a greater adrenocorticotrophic hormone (ACTH) response to corticotrophin-releasing hormone (CRH) has been demonstrated in comparison with a control group [6]. Patients with IBS have shown an altered sympathetic and parasympathetic balance and a lower parasympathetic baseline tone in relation to a control group composed of women. Functional magnetic resonance imaging was used to evaluate brain responses induced by rectal distention. A negative association was identified between the ACTH response to CRH and activity of the anterior cingulate cortex during rectal distention in the control group but not in IBS patients, indicating that gastrointestinal symptoms are exacerbated under stress [7].

In this work we could demonstrate that the response of the rectal wall to insufflation of a balloon that experimentally reproduces the arrival of faecal content to the rectum was influenced by stressful and reassuring sounds. We use a stressful stimulus that physiologically promotes the instinctive human desire to calm a crying baby; failing to calm him or her produces a state of stressful unease in listeners. As a reassuring stimulus we chose a type of music that promotes rest and relaxation [8].

There is supporting evidence that a baby crying is a stressful situation that generates neural responses in known areas of emotional alarm somatic centres such as the amygdala and the hippocampus corresponding to the limbic system, and also the insular cortex. It has been demonstrated that such stimuli can generate neural activation in other areas, such as the midbrain, basal ganglia, prefrontal cortical and internal hypothalamic areas [9].

Despite the randomization of stimuli sequences, the subjects who received initial reassuring stimulus were older. However, no statistically significant differences related to age were observed in a comparison of measurements (Table 4).

These findings demonstrate that there is an interaction between brain and gut that shows that intestinal motility could be a dynamic indicator of stress level and emotional status.

The paradigm of the gut-brain axis must be interpreted with great caution until new studies can reproduce the findings encountered until today. Therefore, we consider that it is necessary to continue with research on the association between emotional states and gastrointestinal tract motility.

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