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Research Article

Cortical Processing of Tonic Ano-Rectal Distensions in Patients with Idiopathic Faecal Incontinence

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Abstract

Aim: The purpose of this study was to investigate the ano-rectal cerebral axis in patients with idiopathic fecal incontinence during sustained distensions in the rectum and in the anal canal.

Methods: 20 women with idiopathic fecal incontinence and 20 healthy age matched women were included. Ano-rectal function was assessed using standard anal manometry together with the sensory response to tonic ano-rectal distension. Cortical electroencephalographic signals were recorded at rest and during 1 minute sustained balloon distension at the urge to defecate threshold in both the anal canal and rectum. Spectral power analysis of the signal during the distension was computed with wavelet analysis, and the coefficients were divided into predefined frequency bands: delta (1 - 4Hz), theta (4 - 8Hz), alpha (8 - 12Hz), beta (12 - 32Hz) and gamma (32 - 70Hz).

Results: Compared to controls, idiopathic fecal incontinence patients had lower anal resting- (- 48 cm H_2O, $p < 0.001$) and squeeze-pressures (-103 cm H_2O, $p < 0.001$). Further, idiopathic fecal incontinence patients had lower thresholds for first sensation of urge (- 36 ml, $p = 0.005$) and tolerated decreased maximum volume in rectum (- 89 ml, $p = 0.002$). There were no differences between idiopathic fecal incontinence patients and healthy controls in any spectral recordings, neither at rest or during ano-rectal distensions.

Conclusion: In this study patients with idiopathic fecal incontinence and healthy controls exhibited similar cortical processing at rest and during sustained balloon distension of the ano-rectum, decreased sensory threshold to maximum tolerable volume in the rectum for the idiopathic fecal incontinence patients.

Keywords: *Electroencephalography, Manometry, Sustained Distension, Wavelet-Analysis*

Introduction

Fecal incontinence (FI) affects approximately 50% of nursing home residents [1,2]. The causes of FI are pleomorphic, and when the aetiology is unclear, the condition is referred to as idiopathic fecal incontinence (IFI). IFI patients typically have structurally intact but weak sphincters, decreased anal sensation [3,4] and altered sensitivity [5]. Pudendal neuropathy is considered to be present in the majority of these patients [6,7].

We have previously shown that IFI patients have increased rectal sensitivity and prolonged latencies of cortical evoked potentials during rapid balloon distension of the rectum [5]. Thus, we hypothesized that IFI patients would exhibit abnormal cortical processing of ano-rectally transmitted sensory input during rapidly induced sustained balloon distension.

The aims of this study were to investigate the resting and squeezing pressure, sensation, and spectral cortical frequency bands in IFI patients and healthy during sustained distensions in the rectum and the anal canal.

Material and Methods

Study volunteers

Twenty women with IFI (age 60.2 ± 13.7) were recruited from the Department of Surgery, Aarhus University Hospital. Colonoscopy or flexible sigmoidoscopy was performed in all patients as part of the standard clinical evaluation. For comparison 20 age matched healthy women with no prior history of FI (age 56.1 ± 11.1) were included. Assessment was done with the Wexner FI score and St Mark's Incontinence score, available in figure 2. Patients completed a bowel diary for a period of 3 weeks prior to enrolment, recording urge- and incontinence-episodes, soiling/seepage and use of pads. IFI patients were defined with Wexner FI score of ≥ 9 and/or ≥ 3 FI episodes during the 3-week period. Exclusion criteria were prior colorectal-, pelvic-, spinal-, or brain-surgery; active use of medication known to interfere with gastrointestinal-, hormonal-, or cerebral-function; or an external sphincter defect > 60° when assessed by endoanal ultrasonography (BK Medicals, Harlev, Denmark). Both IFI patients and controls were examined per protocol by the same investigators at the Department of Surgery, Aarhus University Hospital (November 2012 until February 2014). The study was conducted in conformity with the Helsinki declaration after written informed consent. The protocol was approved by the local Ethics Committee (N-20090008).

Fecal urgency scale

Participants were asked to rate the sensation during sustained balloon distension on a numeric rating scale (NRS), ranging from 0 to 10, where 0 meant "no sensation or need to defecate"; 5 meant "unpleasantness or urge to defecate" and 10 meant "maximum imaginable pain". Sensory thresholds (NRS = 1) were determined by increasing distension pressure until each threshold was reached in the rectum and the anal canal. Distension pressure was then increased until the threshold of unpleasantness or urge to defecate (NRS = 5). The methods and probes have previously been validated and described in detail (8,9).

Manometry assessments

Ano-rectal function was evaluated using standard anal manometry and rectal balloon distension as previously described [10mean age 50 (range, 45- 57].

The anal function assessments were resting and squeeze pressure, the rectal function assessments were first sensation, first urge and maximum tolerable volume.

Balloon distension of the rectum and anal canal

The equipment for distention of the rectum and the anal canal has previously been described in detail [5,11]improved comparable models are required. Twelve rats received rectal balloon distensions on 2 different days separated by 24.3 (SD 24.6, The stimuli were individualized to the urgency threshold as defined above in the rectum and anal canal, and when the threshold was found the same pressure was sustained for one minute.

Experimental protocol

Participants arrived following at least two hours fasting, and were administered a mini enema (Microlax, McNeil, Birkerød, Denmark) 15 minutes prior to examination. Participants were positioned in the lateral position in a comfortable bed in a dimmed room and asked to relax with their eyes open. Electroencephalography (EEG) was recorded for 2 min at resting state. Afterwards the balloons were placed in the rectum and distended until urge to defecate was reached, and EEG was recorded during sustained inflation for one minute. The same procedure was repeated in the anal canal.

Electroencephalography recordings

A 61-channel surface electrode EEG cap (MEQNordic A/S, Jyllinge, Denmark), with the reference electrode positioned between AFz and Fz was mounted with conductive gel to keep impedance below 5kΩ. The cortical EEG signals were recorded in continuous mode with open online filters and a sampling rate of 1000 Hz (SynAmp, Neuroscan, El Paso, TX, USA). In case the urge to defecate subsided during the session, the corresponding EEG was removed before the data processing. EEG data were pre-processed offline in Matlab (R 2019b Mathworks Inc., Natick, Massachusetts, USA) and EEGLAB (v 2019.1), according to figure 1.

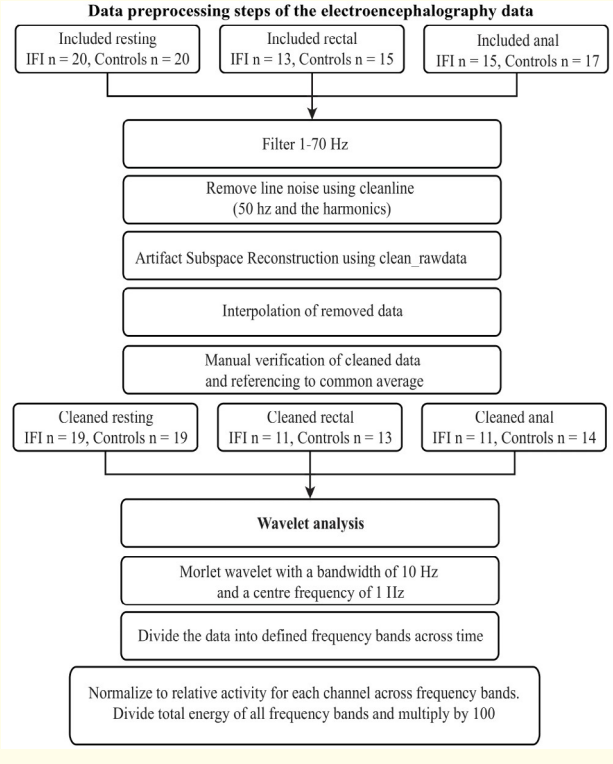

Figure 1: *The preprocessing steps performed to obtain data for spectral analysis.*

Spectral data analysis

Spectral power analysis of the EEG signal was conducted in Matlab (R2019b Mathworks Inc., Natick, Massachusetts, USA). The steps are described in figure 1. The wavelet coefficients were divided into predefined frequency bands: delta (1-4Hz), theta (4-8Hz), alpha (8-12Hz), beta (12-32Hz) and gamma (32-70Hz) and topography was divided into five cortical brain regions: central, frontal, occipital, temporal left, and temporal right.

Statistical analysis

The manometry assessments were tested using a paired t-test or a Wilcoxon rank-sum test, depending on data distribution. Spectral EEG data were analysed by a mixed model analysis with the factors group (patient/healthy) and brain regions (described above) applied to each predefined frequency band. Post hoc Bonferroni correction were used in case of significance. Statistical analysis was performed using Stata version 16.1 (StataCore LLC, College Station, TX).

Results

Anal resting and squeeze pressures were lower in IFI-patients compared to the healthy participants (difference - 48, $p < 0.001$, - 103, $p < 0.001$). No difference for first sensation for rectal distensions were observed between IFI patients and healthy controls. The first urge and maximum tolerable volumes were lower in the IFI patient population (difference -36, p=0.005, -89, p=0.002), detailed data are presented in figure 2. There were no differences between IFI patients and healthy controls in any spectral bands. Topographical plots are shown in Figure 2. To confirm that there were indeed no differences between the groups, absolute values of the wavelet analysis were also computed, but no differences were seen (data not shown).

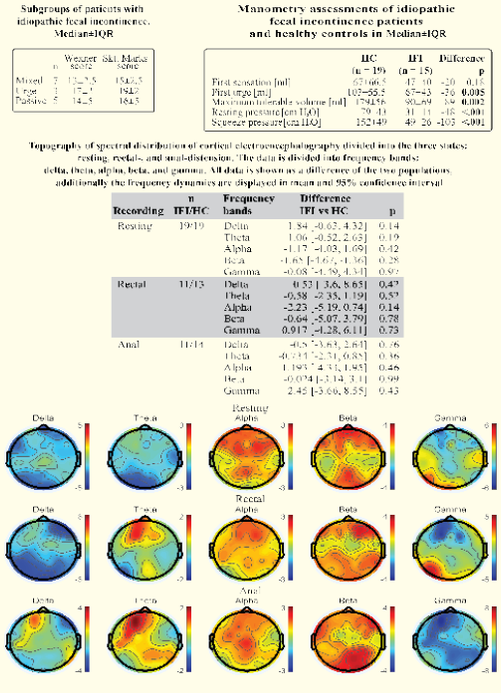

Figure 2: *Data of the patients with idiopathic fecal incontinence (IFI) and healthy controls (HC). Displayed is: Subgroups of the IFI based on the wexner and skt. Marks score. Manometry assessment of IFI and HC, the populations differ in first urge, maximum tolerable volume, resting pressure and squeeze pressure. Only subjects who completed the electroencephalography recordings and were included in the spectral analysis were included in the manometry assessment. Lastly the spectral distribution of the cortical electroencephalography is visualized and the results are displayed.*

Discussion

Despite findings of increased ano-rectal sensibility during tonic balloon distensions in patients with idiopathic fecal incontinence, we did not find any differences in cortical processing of the sensory pathways as compared with healthy volunteers. The stimulation range was wide representing large inter-subject variations [12]. The use of EEG in this paper adds an objective measure of the cortical processing to stimuli using a low cost and non-invasive method. The use of EEG in combination with a tonic stimulation has previously been shown to demonstrate changes in cortical processing and be reliable over time [13].

Comparison with previous studies

We have previously shown that IFI patients have altered cortical awareness in response to rapid balloon distension in the anal canal [5], we are now seeing no alteration in relation to rapidly induced sustained distension. This could be attributed to sustained distension recruiting different afferent nerve fibres as compared to those responding to phasic stimuli.

Continence and defecation are bodily functions that require both cortical awareness, motor responses and a series of intrinsic and spinal reflexes. The main purpose of the ano-rectum is to store and expel stool when appropriate. This process can be divided into entry of fecal matter into the rectum and either accommodate or expulse this matter. When accommodating to its contents the urge to defecate subsides in a healthy person. If rectal contents cannot be expelled, the rectum is capable of accommodating and thus increases its volume with only minor alternations in pressure. Rectal compliance (pressure changes associated with volume infusion) is most pronounced at lower volumes of rectal filling representing active rectal relaxation to accommodate rectal contents. Myenteric- and recto anal excitatory-reflexes will subside with time along with the urge to defecate. Our findings indicate, that the cortical response in this process is unaltered in patients with IFI. The lower sensory threshold at urge to defecate and maximum tolerable volume may thus be attributed to decreased compliance to phasic stimuli of the rectum in this patient category.

Limitations

A limiting factor of this study was the number of patients included in this study is relatively small and there is a risk of a type 2 error. Certainly, numbers are too small for subgroup analysis according to type of IFI. This method does not compare a stimulus that is objectively similar between patients and healthy controls. However, it does compare a stimulus that is rated subjectively similar though a validated scale. This was chosen due to a great inter-individual variation in pressures needed to elicit urge to defecate. The method used for this trial was not controlled over time and because of this the sustained pressure did not necessarily result in a sustained sensation or sensory input. This method was chosen as a safety precaution to not overextend the rectum and anal canal causing permanent damage.

Conclusion

We found IFI patients and healthy volunteers to exhibit similar spectral distribution as a proxy for the cortical processing of sensations during rest and tonic balloon distension of the ano-rectum, despite increased sensory threshold to maximum tolerable volume in the rectum. This may be due to altered compliance of the rectum, while cortical possessing of the tonic sensory input itself is intact. This paper helps understand the interaction of phasic and tonic stimulations in patients with IFI which could be utilized as a part of evidence patient centered care and increased knowledge of the mechanisms underlining IFI.

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