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Short communication

Mechanically evoked cortical potentials: A physiological approach to assessment of anorectal sensory pathways

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HIGHLIGHTS

- Anal and/or rectal hypo- and hypersensitivity are common in many defaecatory disorders.
- Presentation of a novel method to evoke light touch anorectal cortical potentials.
- Selective stimulation of anal canal and rectum, utilizing a 3D printed shield.

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ABSTRACT

Background: Normal defaecation involves activation of anorectal mechanoreceptors responsive to pressure and stretch. The aim of this study was to develop selective anal and rectal mucosal light-touch stimulation suitable for measurement of cortical evoked potentials (EPs) in order to explore the sensory arm of these pathways.
New method: A novel device was manufactured to deliver selective rectal and/or anal light-touch stimulation using a shielded inter-dental brush mounted on a rotating stepper motor (1 Hz, 1 ms, 15° rotation). Resultant somatosensory EPs recorded with a 32-channel cortical multi-electrode array were compared to those elicited by electrical anorectal stimulation (2 mm anal plug electrode [1 Hz, 1 ms, 10 V]).
Results: Eighteen anaesthetized female Wistar rats (body mass 180–250 g) were studied. Electrical and mechanical stimulation provoked similar maximal response amplitudes (electrical anorectal 39.0 μV[SEM 5.5], mechanical anal 42.2 μV[8.1], mechanical rectal 45.8 μV[9.0]). Response latency was longer following mechanical stimulation (electrical anorectal 8.8 ms[0.5], mechanical anal 16.4 ms[1.1], mechanical rectal 18.3 ms[2.5]). The extent of activated sensory cortex was smaller for mechanical stimulation. Sensory inferior rectal nerve activity was greater during anal compared to rectal mechanical in a subgroup of 4 rats. Evoked potentials were reproducible over 40 min in a subgroup of 9 rats.
Comparison with existing methods: Cortical EPs are typically recorded in response to non-physiological electrical stimuli. The use of a mechanical stimulus may provide a more localized physiological method of assessment.
Conclusions: To the authors' knowledge these are the first selective brush-elicited anal and rectal EPs recorded in animals and provide a physiological approach to testing of anorectal afferent pathways.

1. Introduction

The physiology of defaecation and continence is critically reliant on intact anorectal sensation (Palit et al., 2012). The rectum and anus are richly innervated with mucosal receptors sensitive to temperature, pressure and stretch (Duthie and Gairns, 1960) and

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disorders of anorectal sensation are associated with a number of functional bowel problems such as faecal incontinence, chronic constipation and irritable bowel syndrome (Mertz et al., 1995; Chan et al., 2005; Vasudevan et al., 2007; Scott et al., 2011; Burgell and Scott, 2012).

Cortical evoked potentials (EPs) are widely used to investigate the physiology and pathophysiology of sensory function and cortical representation (Chiappa and Ropper, 1982). In man, they are routinely used for clinical diagnosis of demyelinating conditions (McDonald et al., 2001) and in the rodent they have been applied for study of somatic and visceral pathways (Freeman and Sohmer, 1996).

Visceral EPs are primarily elicited by electrical stimulation of the target area as this produces potentials of greatest amplitude and clarity, however the use of electrical stimuli is often criticized due to its non-physiological nature (Pratt et al., 1979). An ideal stimulus for assessment of sensory function is one that mimics physiological function as closely as possible, whilst maintaining precision and control. A number of methods using mechanical stimuli for the generation of EPs have been utilized including tapping and the use of air-puffs with some success (Polley et al., 1999; Sosnik et al., 2001); however application of these methods to the study of luminal organs such as the distal gastrointestinal tract would be technically challenging.

Rapid rectal balloon distension has previously been used in both animals and humans for evoking cortical potentials (Nissen et al., 2013). However this method has limitations, namely the requirement for costly equipment and a high-pressure system with compliant balloons for accurate stimulation. The potentials evoked are usually smaller than electrically evoked potentials and have a longer latency (Hultin et al., 2012).

An alternative approach is to deliver light-touch mechanical stimulation. To the author's knowledge there is no previously published method for recording of cortical EPs in response to selective light-touch mechanical stimulation of the rectum and anus. The development of such a technique would allow specific and detailed exploration of physiological pathways involved in neural control of continence.

2. Aims

The aim of this study was to develop a method to allow selective physiological stimulation of the rectum and anus in the rat, to allow exploration of resultant cortical responses using EPs and to compare these results with EPs obtained using an electrical stimulus.

3. Methods

Experiments were carried out in accordance with a protocol approved by the University College Dublin Animal Ethics Research Committee. The licence was granted by the Irish department of Health and Children (reference: B100/4435). Animals were kept at a 12/12-h light/dark cycle and had access to water and a rodent standard diet *ad libitum*.

A total of 18 female Wistar rats were used. Animals were anaesthetically induced with isoflurane (4%) in oxygen (1 L/min) and then surgically anaesthetized with a 20% solution of 1.5 g/kg i.p. urethane (Sigma, Arklow, Ireland). Femoral vein cannulation was performed to allow administration of fluids and additional i.v. urethane as required. Anaesthetic depth was monitored regularly using both the pedal withdrawal to toe pinch and corneal reflex. A tracheostomy and intubation were performed to prevent airway obstruction.

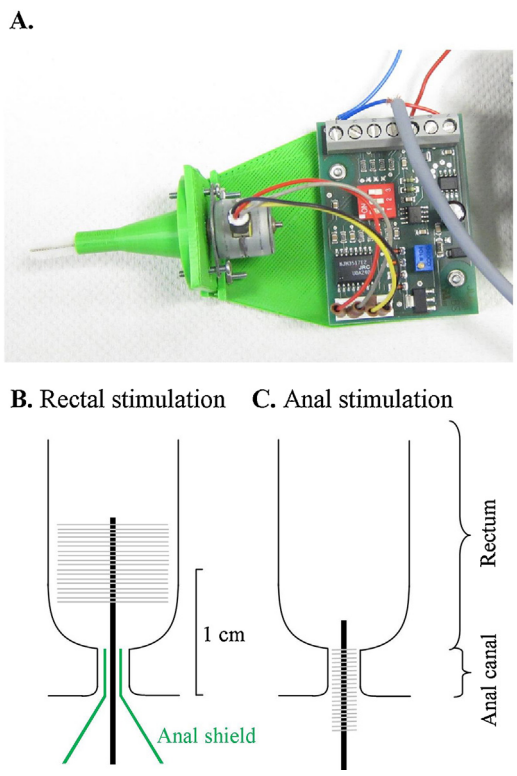

Fig. 1. Photograph of brush stimulator (A) and diagrammatic representation of brush placement during stimulation of the rectum (B), and anus (C).

3.1. Anal and rectal mechanical stimulation

A novel device was developed for mechanical light-touch stimulation. A commercially available interdental brush (2 mm Ø, 1 cm length for anal stimulation and 5 mm Ø, 1 cm length for rectal stimulation, TePe®, Malmö, Sweden) was mounted on a bipolar stepper motor (15M020D1B, Radionics, Dublin, Ireland) with a driver that set a rotation of 15 degrees when triggered (Somotronic101, Radionics, Dublin, Ireland). The shaft of the brush was placed within a 3D-printed (Ultimaker, Geldermalsen, Netherlands) customized shielding device (constructed from polylactic acid) that allowed selective stimulation of the rectum (Fig. 1).

Anal canal stimuli were delivered with the 2 mm brush stimulating the distal 3 mm of the rat anal canal. Rectal stimuli were delivered using the 5 mm brush, and the anal shield *in situ*.

3.2. Electrical stimulation

For electrical anorectal stimulation, a gold plated plug cathode (diameter: 2 mm) was placed in the anal canal and a silver wire anode (diameter: 500 μm) introduced subcutaneously lateral to the external anal sphincter on the left side. Stimulation was delivered at 10 V amplitude with a pulse frequency of 1 Hz and pulse duration of 1 ms as previously reported (Griffin et al., 2011; Evers et al., 2014).

3.3. Recording of somatosensory evoked potentials

A 4 mm × 4 mm craniotomy centred over the area of maximal anal representation (anteroposterior coordinate −0.6 mm, mediolateral +2 mm from Bregma (Griffin et al., 2011)) was made over the right somatosensory cortex. Evoked potentials were recorded using an extra-dural multi-electrode array (flexMEA, Multi Channel Systems, Reutlingen, Germany) consisting of 32 recording electrodes, two reference and two ground electrodes covering an area of