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Kurstjens M[1], Rijkhoff N[1], Borau A[2], Rodríguez A[2], Vidal J[2], Sinkjær T[1]
1. Center for Sensory-Motor Interaction (SMI), Aalborg University, Denmark, 2. Institut Guttmann, Neurorehabilitation Hospital of Barcelona, Barcelona, Spain

INTRAOPERATIVE RECORDING OF ELECTRONEUROGRAPHIC SIGNALS FROM CUFF ELECTRODES ON THE EXTRADURAL SACRAL ROOTS IN HUMAN

Hypothesis / aims of study

Conditional stimulation can be used to inhibit undesired detrusor contractions in patients with a neurogenic bladder [1]. However, a sensor is needed to monitor bladder activity. Because the biocompatibility and reliability of artificial sensors are insufficient for long-term application, the natural sensors in the body may offer an alternative. Animal studies have shown that afferent nerve signals related to bladder activity can be recorded from cuff electrodes placed on the pelvic nerves or sacral roots in pigs [2] and cats [3]. The aim of the present study was to investigate whether afferent nerve signals from the bladder can also be recorded from the extradural sacral roots in human.

Study design, materials and methods

Nerve recordings were performed intraoperatively in 6 patients who underwent implantation of an extradural FineTech-Brindley Bladder System. A laminectomy was performed and the extradural sacral roots were identified. A bipolar cuff electrode (inner diameter 2.6-3.8 mm, length 10 mm) was then temporary placed on the extradural S3 root with the best bladder response to electrical stimulation using a hook electrode and connected to a sterile telemeter. Electroneurographic (ENG) signals were recorded during mechanical stimulation of the S3 dermatome (tapping and stroking by hand), rectum distension (50 ml saline bolus infusions into rectal balloon), fast bladder filling (subsequent 50 ml saline bolus infusions), and bladder contractions (electrical stimulation of the contralateral sacral root). The intravesical pressure (Pves) was measured using a single lumen 5Ch catheter, while the pressure in the rectum (Prect) was measured using a 10Ch balloon catheter mounted against a 18Ch distension catheter. The variance per time bin of the ENG signals was calculated (40 ms for cutaneous and 100 ms for bladder and rectal responses), and responses were quantified by the signal-to-noise ratio (SNR: the ratio of the variances during peak neural activity and the background noise, 1 s average for bladder and rectal responses).

Results

Tapping and stroking the sacral dermatome evoked clear ENG responses in all 6 patients. The SNR of ENG responses was largest during tapping and ranged from 1.43±0.41 to 5.25±0.98 (n=20 per patient). Prect did not increase sufficiently during rectal distension in the first three patients to evoke clear ENG responses. After reducing the size of the balloon and infusing 6-8 subsequent boluses for distension in the last three patients, Prect reached peak values of 68-104 cmH_2O but ENG responses remained small. The largest increases in pressure (range: 18-67 cm H_2O) and ENG responses (range SNR: 0.06-0.30) were obtained with repetitive withdrawal and fast re-infusion of 50 ml in the full balloon. ENG responses to bladder filling were present in 5 out of 6 patients. Responses during filling were mainly phasic, but when the pressure after filling was sufficiently large, a tonic component was maintained (Figure 1). The first increases in ENG were recorded after infusing 150±145 ml and a Pves of 32±8 cmH_2O (n=4) was reached. Peak ENG responses with SNR of 0.25-0.53 were recorded when intravesical pressures reached 80-140 cmH_2O. Increases in ENG were present during bladder contractions in 4 out of 5 patients. Stimulation artefact prevented recording of ENG during stimulation. ENG responses with SNR = 0.12-0.67 were however present immediately after stimulation was stopped, and decreased with decreasing pressure.

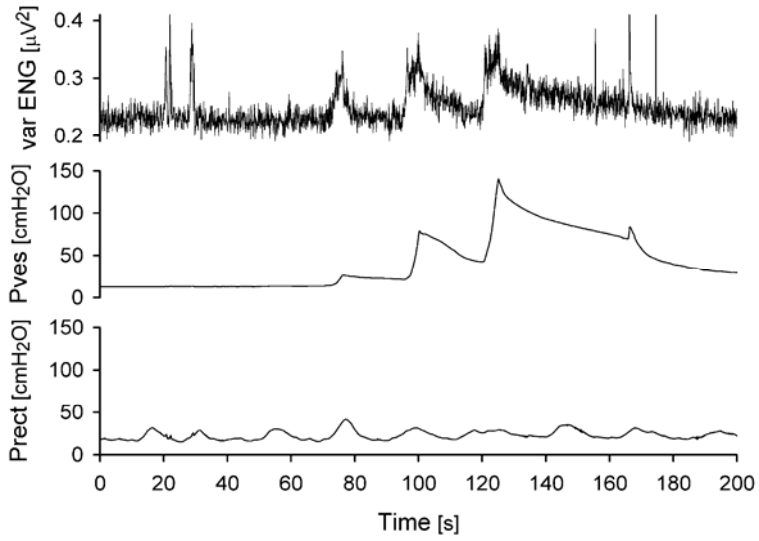

Figure 1: ENG responses during bladder filling in patient 5. The first infusion did not increase Pves but large ENG responses were evoked by catheter pulling during coupling and decoupling of the syringe. Large increases in pressure and ENG responses were obtained during three further infusions.

Interpretation of results

Mechanical stimulation of different afferent sources evoked similar ENG responses on the same sacral root. Responses from the dermatome were larger in amplitude as the cutaneous mechanoreceptors are innervated by larger diameter nerve fibers than the visceral organs. The phasic nature of the ENG responses is well suited to detect sudden detrusor contractions, but more sophisticated signal processing methods are needed to reliably distinguish sensory information from the bladder from other signal sources.

Concluding message

Afferent nerve activity from the bladder and other pelvic organs can be recorded from the extradural S3 sacral nerve roots in human, but the small signal amplitudes and various sources that contribute to the sacral root nerve activity indicate that improvements are needed in recording quality and selectivity for a chronic application.

References

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