Predicting Neurogenic Detrusor Overactivity by Monitoring Urethral Sphincter EMG

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Abstract

The aim of this study was to evaluate the feasibility of using external urethral sphincter EMG to estimate the onset of detrusor contractions in patients with both neurogenic detrusor overactivity (NDO) and detrusor sphincter dyssynergia (DSD).

Detrusor pressure and urethral sphincter EMG was recorded in 23 neurogenic patients during slow artificial bladder filling. The time delay between the onset of a detrusor contraction and the onset of sphincter EMG activity was calculated together with the detrusor pressure increase related to this delay.

Of 23 patients enrolled, 12 patients showed both NDO and DSD. Of these 12 patients, 10 had a strong correlation between detrusor pressure and urethral sphincter EMG. In these 10 patients, the average time between the onset of a detrusor contraction and the onset of EMG activity was 3.6 ± 2.7 s. The average pressure increase at the onset of EMG was 8.0 ± 9.9 cmH2O.

This study demonstrates the feasibility of using sphincter EMG to estimate the onset of a detrusor contraction in selected patients. In 9 out of 10 patients with strong correlation between NDO and DSD, the detection was sufficiently early in time to suppress NDO before the detrusor pressure becomes too high.

1. INTRODUCTION

Neurogenic detrusor overactivity (NDO) is a common urodynamic observation in neurologically impaired patients (e.g., those with spinal cord injuries, multiple sclerosis, Parkinson’s disease). It is characterised by involuntary detrusor contractions during the filling phase, which may be spontaneous or provoked. NDO is frequently associated with urethral sphincter overactivity, resulting in detrusor-sphincter dyssynergia (DSD). The consequence of this combination is often high intravesical pressures followed by incontinence and low bladder capacity. If left untreated the high pressures may cause upper urinary tract damage.

The first-line treatment of NDO is oral administration of anticholinergic drugs. However, many patients are refractory to the medication or have dose limiting side effects. In these cases, ablative surgery is usually considered in order to preserve kidney function and to enlarge the functional bladder capacity. An alternative treatment option is electrical stimulation. It has been shown that electrical stimulation of pudendal nerve afferents can inhibit bladder contractions in patients with NDO and that bladder capacity can be increased by continuous [1] as well as conditional stimulation [2].

In principal, inhibition of the detrusor is only necessary during an involuntary contraction. Hence, stimulation could be turned off between contractions, leading to a number of possible advantages. Power consumption may be reduced and electrode lifetime may be extended. Furthermore, continuous stimulation could lead to habituation, which would be minimized or prevented by conditional stimulation. Our future goal is the development of an implantable neuroprosthesis that utilizes conditional stimulation in order to treat NDO. However, the need for a non-catheter based monitoring of bladder activity is essential if such a stimulation scheme is to be used in an implant. One option is to record bladder related afferent nerve activity using cuff electrodes placed on the sacral roots [3, 4]. Another option could be the use of intramuscular EMG as a feedback signal [5] and in our case pelvic floor
EMG. Therefore, the objective of this study was to evaluate the feasibility of predicting NDO by monitoring urethral sphincter EMG.

2. METHODS

The local Ethics Committee at Institut Guttmann approved the study and informed consent from all patients was obtained. A cystometry with slow fill rate (≤ 20 ml/min) was performed on 23 neurogenic patients (13 males, 10 females). Vesical pressure (P-ves) and abdominal pressure (P-abd) were measured using an 8Fr double lumen water filled catheter and a 9Fr water filled rectal balloon catheter, respectively. Two insulated fine wire electrodes were inserted into the periurethral musculature for EMG recording of the external urethral sphincter (EUS).

Inclusion criteria were a history of NDO and DSD, bladder capacity below 500 ml and age above 18 years. Participants were not asked to discontinue medication prior to participating in this experiment. A correlation analysis between P-det and the rectified, time-averaged activity of EUS EMG was performed. The time delay (Δt) between the onset of the first detrusor contraction and the onset of sphincter activity was calculated together with the increase in detrusor pressure (ΔP) related to this delay (see figure 1).

3. RESULTS

Of the 23 patients enrolled in the study, 12 showed both NDO and DSD before reaching the maximum allowed bladder capacity. Eight patients showed no NDO during the slow filling cystometry or they had too large a bladder capacity, two showed no sign of DSD and recordings in one patient failed due to technical reasons. Of the 12 patient with both NDO and DSD, 10 patients had a strong correlation between detrusor pressure and urethral sphincter EMG. The strong correlation allows the use of EMG as a predictor for detrusor contractions. In these 10 patients, the average delay between the onset of a detrusor contraction and the onset of EUS EMG activity was 3.9 ± 2.7 s. The average pressure increase related to this delay was 8.0 ± 9.9 cmH2O (see figure 2).

4. DISCUSSION AND CONCLUSIONS

Pressure activated electrical stimulation of pudendal nerve afferents with a threshold of 10 cmH2O has previously been shown to inhibit bladder contractions sufficiently early to prevent leakage as well as to maintain a safe
storage pressure [6]. In the current study, in 9 out of 10 patients the onset of the sphincter contraction occurred before the detrusor pressure exceeded 10 cmH2O (see figure 2). Thus, stimulation could be applied earlier in these patients if activation was based on a rise in EMG activity rather than on a rise in pressure.

An animal study using cats reported similar results regarding the detection of the onset of bladder contractions, but in this study ENG recordings using cuff electrodes placed on the sacral roots were used [4]. 29 out of 30 contractions were detected within 6 ± 8 s. and with an average pressure increase related to this delay of 9 ± 8 cmH2O. The feasibility of recording bladder related nerve activity from sacral roots has also been demonstrated in humans [3].

There are both advantages and disadvantages to ENG and EMG based detection methods. A cuff electrode placed on the sacral roots will pick up activity from multiple organs (e.g. skin, rectum and bladder). The recorded ENG signal will contain direct bladder related nerve activity but it is non-selective and the signal to noise ratio (SNR) is small compared to the EMG SNR. The signal-processing task of separating the bladder related component from the overall activity will be complex and may result in many false-positive detections. Recordings from the sacral roots on the other hand do not require the presence of DSD and could therefore in theory be used in every patient with NDO.

With an EMG approach, the recorded signal will contain an indirect bladder related muscle activity, it will thus be more selective, the SNR will be higher and placing the electrode will require less surgery. The number of false-positive detections may thus be smaller but the detection principal will only work in patients with both NDO and DSD.

This study demonstrates the feasibility of using sphincter EMG to estimate the onset of a detrusor contraction in selected patients. In 9 out of 10 patients with strong correlation between NDO and DSD, the detection was sufficiently early in time to suppress NDO before the detrusor pressure becomes too high. An automatic, event driven stimulation scheme with a catheter based monitoring of bladder activity have shown that the method of conditional stimulation works [6]. However, the catheter based monitoring is not feasible in an implant but monitoring striated sphincter activity may be a viable solution. Although the setup in this experiment is not suitable in a clinical setting, the method is promising and warrants further investigation. An alternative to the EMG approach could be monitoring of ENG from the pudendal nerve, which innervates the EUS.

References


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