

Experimental Treatment of Neurogenic Detrusor Overactivity in Spinal Cord Injured Patients by Automatic Event Driven Electrical Stimulation

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Abstract

The aim of this study was to evaluate the feasibility and clinical relevance of automatic event driven electrical stimulation of the dorsal penile/clitoral nerve in treatment of neurogenic detrusor overactivity (NDO) in individuals with spinal cord injury (SCI).

Detrusor pressure (P_{det}) was monitored during at least two sessions of natural bladder filling in each of the 16 patients examined. In one session an ordinary natural filling was recorded and in the subsequent session P_{det} was furthermore used to trigger stimulation when the pressure exceeded 10 cmH₂O.

In 81% of the patients bladder capacity was increased and storage pressure decreased as a result of automatic event driven electrical stimulation. During the stimulated filling P_{det} never exceeded 55 cmH₂O and the storage pressure is thus sufficiently low to prevent kidney damage.

1 Introduction

NDO is a common urodynamic observation in patients with SCI. It is characterised by involuntary detrusor contractions during the filling phase which may be spontaneous or provoked. Patients with NDO often have high intravesical pressures, low bladder capacity and suffer from incontinence. If left untreated the high pressures can lead to upper urinary tract damage.

The first-line treatment of NDO is medication, such as the use of anticholinergic drugs. Many patients are however refractory to this treatment or they have dose limiting side effects. In that case surgical options are usually considered in order to increase the functional bladder capacity

and decrease the maximum detrusor pressure during the filling phase and hereby prevent kidney damage [1]. An alternative treatment option is electrical stimulation. It has been shown that electrical stimulation of pudendal nerve afferents can inhibit bladder contractions in SCI patients and that bladder capacity can be increased by continuous [2] as well as conditional stimulation [3]. The aim of this study was to evaluate the feasibility and clinical relevance of automatic event driven electrical stimulation of the dorsal penile/clitoral nerve in treatment of NDO in individuals with SCI.

2 Methods

The study was approved by the local Ethics Committee and informed consent was obtained from all patients. A total of 16 SCI patients have been examined (14 M, 2 F). Inclusion criteria were occurrence of NDO at bladder capacities below 500 ml, age over 18 years and complete or incomplete suprasacral SCI. Participants were not asked to discontinue medication prior to participating in this experiment. Stimulation was conducted using surface electrodes placed on the base of the penis or on the clitoris and parameters were: 20 pulses/s, pulse width 200 μ s and amplitude two times threshold for elicitation of the bulbocavernosus reflex.

P_{ves} and P_{abd} were measured using a custom made portable device [4] and electrical stimulation was triggered based on the calculated P_{det} . In each patient at least one session of both ordinary and stimulated natural filling were recorded.

In the stimulated filling stimulation was applied when P_{det} exceeded 10 cmH₂O and it was stopped again in any of the following cases:

- Automatically, when P_{det} had been under the threshold for a period of 10 s.
- Manually, when a leakage was detected (by visual inspection).
- Manually, when stimulation had been on for more than 2 minutes without a decrease in pressure.

In order to evaluate the effect of penile/clitoral nerve stimulation 4 parameters were calculated/extracted (see fig. 2 and 3):

- Bladder volume at first contraction during treated filling. *
- Bladder volume at the time of leakage in treated filling. **
- The average peak pressure of P_{det} during spontaneous contractions in the ordinary filling.
- The average peak pressure of P_{det} during suppressed contractions in the treated filling.

* Calculated on the assumption of linear urine production during the time of treated filling.

** Measured as volume leaked + residual urine at the end of the treated filling.

3 Results

Stimulation increased bladder capacity in 13 out of 16 patients (81%). In 2 patients stimulation was unable to inhibit the first undesired contraction and leakage occurred. Another patient could not tolerate the stimulation.

Figure 1 shows 3 recordings from the same patient. In trace 2 the stimulation is triggered each time P_{det} rises above 10 cmH₂O. It is clear that stimulation decreases the maximum P_{det} (see the zoom in fig. 1) during a spontaneous contraction and increases the filling time.

Figure 2 shows the individual bladder capacities after the treated filling. It is assumed that had the stimulation not started, leakage would have occurred. The bladder volume at the time of the first contraction is thus assumed to be the bladder capacity without stimulation.

Figure 3 shows the individual average peak pressure of P_{det} during ordinary and stimulated natural filling together with the corresponding mean and standard deviation.

Results from the 13 good responders indicate that it is feasible to treat NDO by event driven electrical stimulation. An average bladder capacity increase of 53% was obtained. The average peak detrusor pressure during suppressed contractions in the stimulated filling was 28 cmH₂O (range 12 - 55 cmH₂O) and is thus sufficiently low to prevent kidney damage.

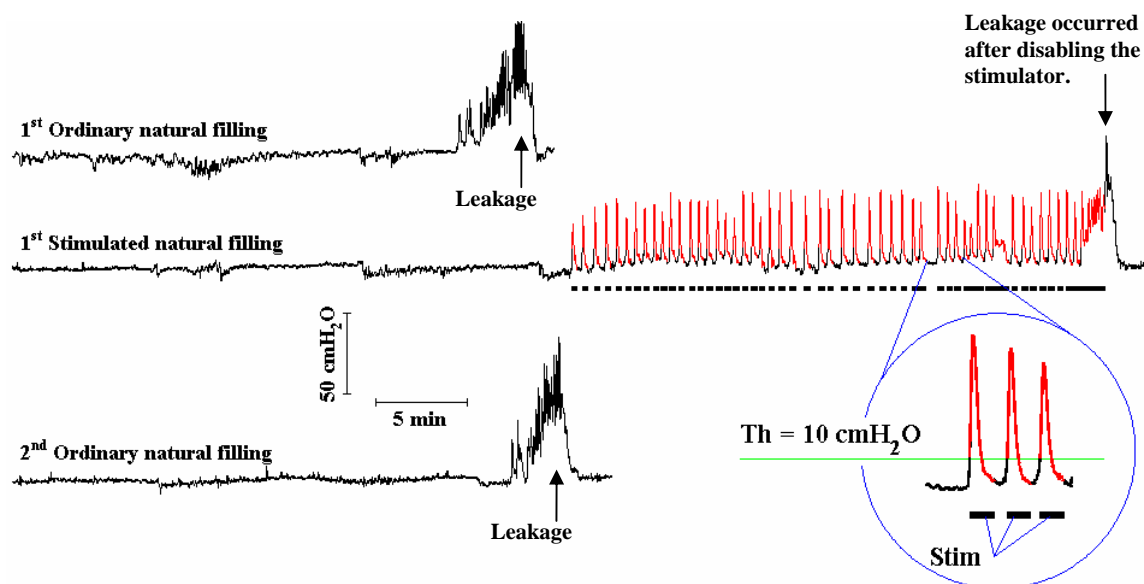
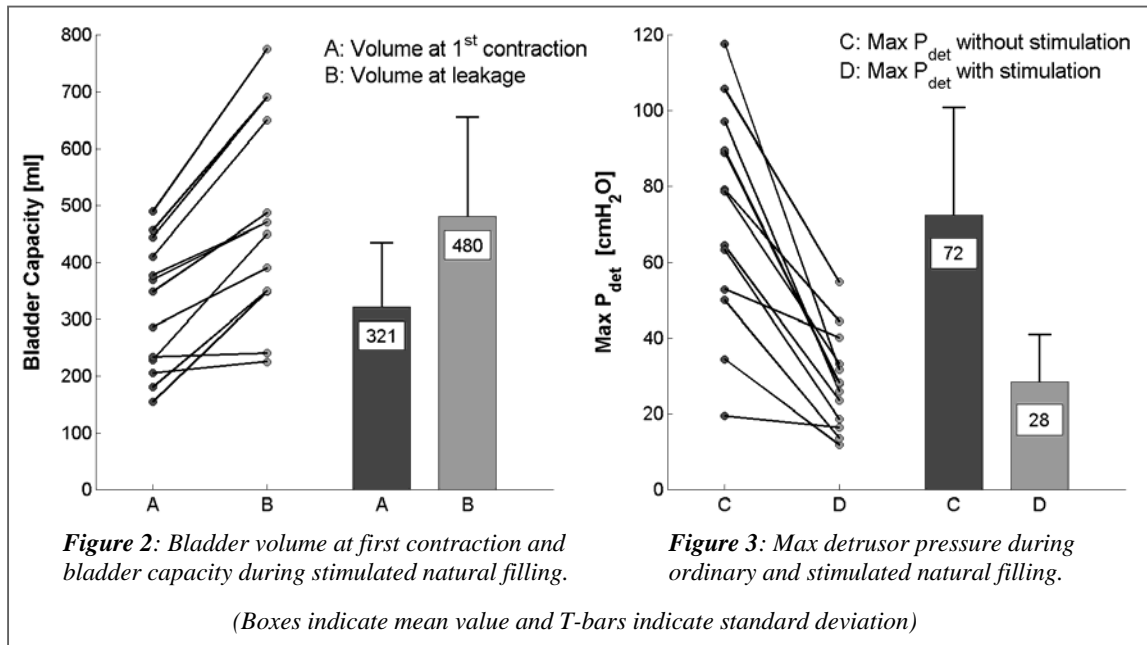


Figure 1: Recordings of P_{det} during 3 natural bladder fillings from the same patient. Bladder is empty at the beginning of all 3 traces and the time of leakage is indicated an arrow.



4 Discussion and Conclusions

In 81% of the patients bladder capacity was increased and storage pressure decreased as a result of automatic event driven electrical stimulation. Although the setup in this experiment is not suitable in the chronic setting, the treatment modality is promising. Today implants stimulating pudendal nerve afferents are available but they use continuous stimulation, which may have long-term side effects such as tissue damage due to the energy deployed during stimulation or habituation in the reflex arcs involved. Another argument against continuous stimulation is that the need for constant current delivery may shorten both battery and electrode life in the implanted device. This makes it relevant to investigate event driven stimulation. Steps are being taken in order to develop a non-catheter based monitoring of bladder activity, since this is needed in order to apply stimulation automatically.

References

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