

# Demand Driven Short Duration Electrical Stimulation of the Dorsal Penile/Clitoral Nerve Can Increase Bladder Capacity in Spinal Cord Injured Patients

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## Abstract

**Background:** Undesired detrusor contractions during the bladder storage phase can lead to incontinence, low bladder capacity and urine reflux.

**Introduction:** The aim of our project is to develop a system, which allows treatment of incontinence due to hyperreflexic contractions by a closed loop electrical stimulation system.

We investigated the effect of event driven short duration electrical stimulation of the dorsal penile/clitoral nerve on bladder capacity during cystometry in these patients.

**Material and methods:** A handheld bipolar electrode (Dantec-Medtronic) was placed on the skin over the dorsal penile/clitoral nerve. Electrical stimulation was started in response to bladder contraction and continued until the bladder pressure started to decline. Stimulation length 7-20 s. Pulse duration: 100  $\mu$ s; pulse rate: 20 pulses/s; amplitude 12-34 mA.

**Results:** 4 patients had increased cystometric capacity at leakage-point as compared to routine cystometric capacity at leakage-point, by 8, 115, 123 and 191%. One patient had capacity decreased by 2%.

**Conclusion:** This study shows that event driven short duration electrical stimulation of the dorsal penile/clitoral nerve can increase cystometric capacity in spinal cord injured patients.

## 1. Introduction

The aim of our project is to develop a system, which allows treatment of incontinence by a closed loop electrical stimulation system.

The higher centres in the brain and brainstem exert an inhibitory effect on spinal reflexes. A spinal cord lesion impairs or eliminates this inhibitory action, leaving the innate tendency of the reflex-arches to increase muscle-tone in the regions supplied

unhindered. In the urinary tract two pathophysiological entities evolve: detrusor hyperreflexia and detrusor-sphincter dyssynergia. Detrusor hyperreflexia denotes the spasticity in the bladder-muscle (detrusor), which may contract during the bladder storage phase, leading to incontinence, low bladder capacity and reflux of urine to the kidney. Detrusor-sphincter dyssynergia denotes the spasticity in the urethra sphincter, which may contract during the bladder voiding phase, leading to prolonged and incomplete voiding.

Detrusor hyperreflexia and detrusor-sphincter-dyssynergia are usually present in combination leading to a multitude of symptoms like incontinence, stone formation, urinary tract infections, urosepsis, urine reflux, and in severe cases kidney failure making dialysis or kidney transplant necessary.

Treatment to prevent undesired hyperreflexic bladder contractions is based on three principles: medication, surgical bladder augmentation or dorsal rhizotomy. Medication is rarely sufficient to abolish unwanted contractions, and it aggravates the patients' predisposition to constipation. Augmentation establishes an acontractile bladder or bladder-intestine-reservoir. Dorsal rhizotomy is performed at the sacral level, disrupting reflex-arches involving the pelvic organs among other the one leading to detrusor hyperreflexia. The bladder becomes acontractile, but there are side effects like impotence, lowered fertility in men and constipation.

In this study we focused on treatment of detrusor hyperreflexia by event driven short duration electrical stimulation of the dorsal penile/clitoral nerve. This nerve is exclusively afferent and supplies the genital-perigenital area. It forms the afferent part of a reflex-arch whose efferent part is the motoneurons to the detrusor and the urethra. Activity in the afferent part is inhibitory to the efferent part. Earlier studies have shown that continuous electrical stimulation on the dorsal penile/clitoral nerve during cystometri leads to increases in cystometric bladder capacity in humans and experimental animals [3-5]. In addition short

duration electrical or magnetic stimulation for 5 s of the S3 roots has been shown to abolish detrusor hyperreflexia contractions provoked by rapid injections [1;2].

Our aim was to investigate the effect of event driven short duration electrical stimulation of the dorsal penile/clitoral nerve on bladder compliance in spinal cord injured patients during normal infusion rate cystometries.

## 2. Material and Methods

Approval for this study was obtained from the local ethical committee. 5 patients, 3 male 2 female, age 22-61 years, volunteered to participate. They all had a spinal cord injury (patient numbers 3 and 5, both female, had incomplete lesions and some bladder sensation) and showed hyperreflexia during routine cystometry. Urinary tract infections were ruled out by dipstick test and urine culture. Anti-cholinergic medication was not discontinued before the study.

An custom-made battery-driven stimulator was connected to a handheld bipolar electrode (Dantec-Medtronic) which was placed on the skin over the dorsal penile/clitoral nerve and 1-3 cystometries were performed using standard cystometri equipment, infusionrate 60 ml/min (Duet, Dantec-Medtronic). Electrical stimulation on the dorsal penile was conducted manually and started when a bladder contraction was observed. Stimulation parameters were pulse-duration: 100 ms; pulse rate: 20 pulses/s; amplitude 12-34 mA. Stimulation was stopped when the bladder pressure decreased. Duration of stimulation was usually 7-15 s. Repeated stimulations were performed during one cystometry. Inhibition by short duration electrical stimulation continued during the cystometry until leakage, patient discomfort or a cystometric capacity more than 500 ml in which case the infusion was terminated at 600 ml.

## 3. Results

4 patients had an increased cystometric capacity at leakage point during electrical stimulation as compared to routine cystometric capacity at leakage point. Their capacity was increased by 8, 115, 123 and 191%, respectively In 1 patient the capacity decreased by 2% (Fig 1).

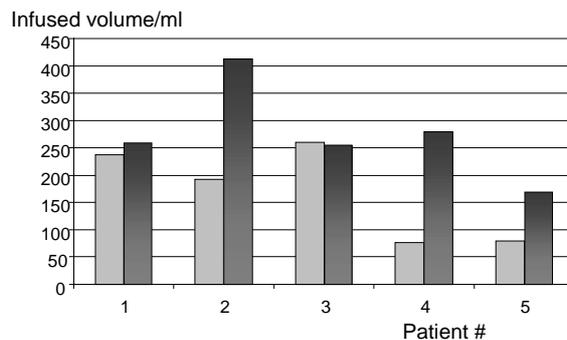


Fig 1.

Data from the 5 patients. Patient 3 and 4 are women. Patients 3 and 4 have incomplete lesions.

Left column represents cystometric capacity at leakage point without electrical stimulation; right column represents cystometric capacity at leakage point with electrical stimulation.

The study also showed that effective inhibition of unwanted detrusor contractions could be performed repeatedly during bladder fillings (fig 2 and fig 3).

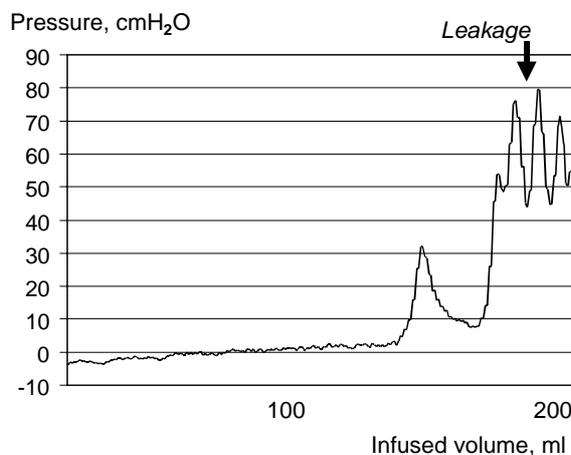


Fig 2

Control cystometry. Data from patient number 2, male with complete C5-C6 lesion. Note selflimiting contraction at 150 ml followed by confluent contractions which leads to leakage at 192 ml.

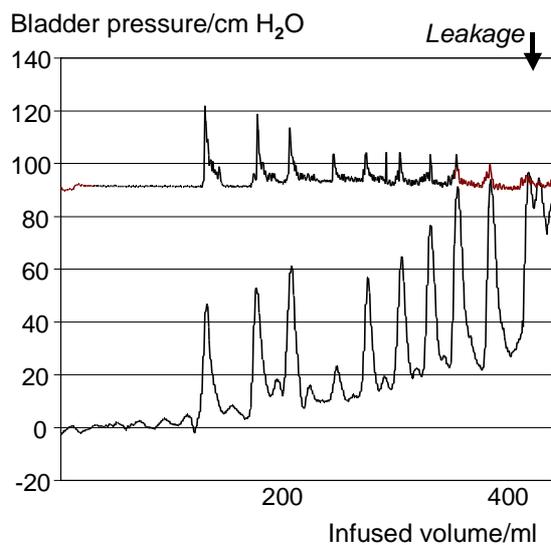


Fig 3. Cystometry with treatment. Same patient as in fig 2. Note change of scales. Curve at the top is EMG, 9 stimulation artefacts are clearly seen. Electrical stimulation and infusion was terminated at 412 ml because of patient discomfort, and the pattern of confluent contractions and leakage followed.

#### 4. Discussion

Increased capacity during repeated cystometries is a regular finding. In this study no control cystometry was performed after the up to 3 treatment cystometries. Still, we ascribe the increased cystometric capacity to the treatment for three reasons: the contractions were clearly eliminated during electrical stimulation; the possibility of up to 9 self-limiting detrusor contractions during one cystometry is small; the increment in capacity is larger than seen in spontaneous increments during repeated cystometries.

#### 5. Conclusion

This study shows data on increased cystometric capacity in spinal cord injured patients during event driven short duration electrical stimulation on the dorsal penile/clitoral nerve

#### Acknowledgement:

This study was supported by the Danish Board of Health Sciences

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