Chapter 7

Simultaneous Sacral and Tibial Transcutaneous Electrical Nerve Stimulation: urodynamic evaluation

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Introduction

Electrostimulation is thought to modulate the neural behaviour of the bladder and is applied for example in patients with symptoms of Over Active Bladder (OAB) syndrome (1). Intravaginal stimulation, percutaneous tibial nerve stimulation, and sacral neurostimulation all have been reported to modify detrusor function (2-4). Neurostimulation using Transcutaneous Electrical Nerve Stimulation (TENS) has been advocated for the treatment of detrusor over activity, stress incontinence and interstitial cystitis (IC) (5). The mode of action of TENS was initially thought to be due to altered sensation or to completion with or masking of pain (6, 7).

Because clinical results were promising, studies assessed various aspects of this therapy. Compared to placebo, there are conflicting publications reporting no significant changes in urodynamics versus significant changes in first desire to void, maximum cystometric capacity and threshold volume in the suprapubic TENS group. TENS over the S2 - S4 dermatome has been studied using both clinical and urodynamic parameters, showing that it might improve uro dynamical parameters. S2- S4 TENS has been solely compared to no TENS, sham TENS, suprapubic TENS and tibial nerve TENS solely. PTNS has been introduced for the treatment of lower urinary tract dysfunction. The precise mode of action of electrostimulation is unclear, but in literature is believed “to restore the balance within the central nervous system” (11-13).

The International Continence Society (ICS) has defined overactive bladder (OAB) syndrome, as urgency with or without urge incontinence, usually with frequency and nocturia, in the absence of proven infection or obvious pathology. and recognized OAB as a significant symptom complex syndrome affecting millions of people worldwide. In our center we have a very specific patient population. Most patients were refractory to conventional therapy, such as, pelvic floor muscle exercises, biofeedback training, intravaginal electrostimulation, PTNS and Sacral Nerve Stimulation (SNS) as well. In literature the effect of neurostimulation at the level of the n. tibialis (invasive: PTNS) and direct stimulation on the dorsal sacrum (neuromodulation or TENS: S2-S3) have been described. The effect of the procedure has been attributed to stimulation of the afferents
to the bladder. Both procedures have been used at our institution with varying success. Some patients appeared to be refractory to either procedure. In order to increase the success rate we have tried if the combination of both procedures would increase yield of the stimulation.

We decided to combine TENS on the tibial nerve and TENS applied at the S2-S4 foramina. We performed this study to quantify the acute effect of one single application of TENS in patients with symptoms of the overactive bladder syndrome using urodynamic parameters.

**Materials and Methods**

Forty consecutive female patients diagnosed with urgency/frequency and/or urge incontinence, but without stress incontinence and/or combined incontinence were included in a prospective study. Before urodynamic measurements all patients underwent comprehensive evaluation, including patient history, physical examination, urinary system ultrasound and a voiding diary.

To investigate the effect of TENS on urodynamic parameters in patients with symptoms of the OAB syndrome, we used the UD-2000 (Medical Measurement Systems, Enschede, the Netherlands) and a four fold microtip catheter (Gaeltec®) with three urethral and one bladder sensor during urodynamic evaluation. Filling rate was 30 ml/ min and we stopped if patients had a strong desire to void. In all patients two urodynamic investigations were performed in succession. Urodynamics were performed according to ICS procedures.

Patients were submitted to urodynamics (group I, n=20) or urodynamics plus TENS (group II, n=20) based on the availability of the pelvic floor physiotherapist during the study period. If the pelvic floor physiotherapist was present both investigations were performed simultaneously as described, if not present, only urodynamics were performed and TENS has been performed during a separate outpatient appointment. The investigation was a diagnostic procedure and not a treatment. Urodynamics of both groups have been compared retrospectively. The investigation was a diagnostic procedure and not a treatment. Urodynamics of both groups have been compared retrospectively.
TENS was given during urodynamics during 20 minutes. All patients had two urodynamic evaluations. Patients were informed about the combined form of urodynamics and TENS.

Measurements were performed during filling cystometry with a filling rate, at 30 ml/min. Stimulation parameters were set to a burst of 2 Hz with pulse duration of 200 μsec and a frequency of 20 Hz. Stimulation intensity was adjusted individually to a level just below that giving rise to unpleasant sensation. We used surface electrodes made of carbon conductive rubber of 5 x 6 cm each. One was placed over the sacrum at the S2-S4 foramina and one over the tibial nerve just above the medial malleolus on the same side. In order to establish a good electrical contact, electrodes were incorporated in a wet sponge. Urodynamics procedures were performed and assessed according to ICS procedures by an experienced clinician in our department and by a pelvic floor physiotherapist. At the end of the second bladder filling when the patient has a normal desire to void, electrostimulation was stopped and “permission to void” is usually given. Printouts of the urodynamic evaluation with and without TENS were assessed by an urologist. The urologist was blinded to the treatment group. We documented maximal detrusor pressure at micturition (cm H2O), first sensation of bladder filling (ml), cystometric capacity (ml), urethral pressure (cm H2O) micturition volume (ml) and peak flow (ml/sec). Rectal pressure was measured with a rectal balloon as a representative of the abdominal pressure (table). Statistical analysis was performed using Wilcoxon and paired T-tests in SPSS 12.1. Significance was defined as p < 0.05.

**Results**

All patients had been treated before with pharmacotherapy (44.3%), surgery (56 %) including colposuspensus and urethral dilatation or self-catheterization or even SNS (3%). Pelvic floor physiotherapy such as biofeedback training and/or intravaginal electrostimulation was performed in all patients. The mean age of patients in group I was 37 years (range 31-65). Nine patients were diagnosed with urgency/ frequency, ten patients with urgency/frequency and urge
incontinence and one patient with urge incontinence. In this group, there were no significant changes between urodynamic parameters of both urodynamic evaluations. The mean age of patients in group II was of 36 years (range 30-65). Ten patients were diagnosed with urgency/ frequency, nine patients with urgency/ frequency and urge incontinence and one patient with urge incontinence. By comparing both urodynamic evaluations in group II; it appeared that the first sensation of bladder filling, cystometric capacity, micturition volume, urethral pressure and peak flow showed statistical significant improvement (p < 0.05) during TENS (table 1).

Prior to TENS no involuntary detrusor contractions during bladder filling were registered in this patient population. However, as an expression of detrusor overactivity, a decreased maximum cystometric capacity was observed at which patients could no longer delay micturition. By comparing the cystometric capacity and the micturition volume, there seems to be a relevant post-void residual (PVR). However, this was due to the fact that some patients were unable to void completely or even to void at all during urodynamics, because they were asked to refrain from straining or inhibited due to the urodynamic setting. Ultrasonography of the bladder prior to urodynamic investigation showed no relevant PVR in the studied patient population. There were no significant differences between the first filling of the patients in group I and group II.
An acute effect of one application of TENS applied simultaneously to the tibial nerve and to S2-S4 foramina on bladder function using urodynamic parameters was demonstrated in patients with the OAB syndrome. Whether the findings represent the clinical effect of TENS in patients with complaints of OAB symptoms, needs to be clarified.

It appeared to be possible to combine TENS applied simultaneously to the tibial nerve and to S2-S4 foramina and to detect sensitive urodynamic parameters as First Sensation of bladder Filling (FSF), bladder capacity, and peak flow.

### Table 1. Urodynamic parameters before and during TRANS (significant if p < 0.05).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (n=20) Without stimulation</th>
<th>Group II (n=20) With Stimulation</th>
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<tr>
<td></td>
<td>First Filling (± SEM)</td>
<td>Before First filling (± SEM)</td>
</tr>
<tr>
<td></td>
<td>90,2 ± 10,9</td>
<td>63,0 ± 3,8</td>
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<tr>
<td>Intravesical pressure (cm H2O)</td>
<td>89,1 ± 7,4</td>
<td>ns</td>
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<tr>
<td></td>
<td>62,9 ± 9,0</td>
<td>43,2 ± 2,8</td>
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<tr>
<td>Abdominal pressure (cm H2O)</td>
<td>64,1 ± 6,2</td>
<td>ns</td>
</tr>
<tr>
<td>Detrusor pressure (cm H2O), during micturition</td>
<td>35,2 ± 7,8</td>
<td>37,2 ± 36,8</td>
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<tr>
<td></td>
<td>36,7 ± 5,4</td>
<td>ns</td>
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<tr>
<td>First sensation of bladder filling (ml)</td>
<td>164,6 ± 31,6</td>
<td>195,7 ± 32,2</td>
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<td></td>
<td>170,5 ± 29</td>
<td>ns</td>
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<tr>
<td>Cystometric capacity (ml)</td>
<td>337,3 ± 40</td>
<td>367,9 ± 40,0</td>
</tr>
<tr>
<td></td>
<td>340,3 ± 39</td>
<td>ns</td>
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<tr>
<td>Micturation volume (ml)</td>
<td>190,3 ± 30</td>
<td>197,6 ± 42,6</td>
</tr>
<tr>
<td></td>
<td>190,5 ± 32</td>
<td>ns</td>
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<tr>
<td>Average urethral pressure (cm H2O)</td>
<td>169,1 ± 15,0</td>
<td>154,6 ± 11,4</td>
</tr>
<tr>
<td></td>
<td>169,0 ± 12</td>
<td>ns</td>
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<tr>
<td>Peak flow (ml/s)</td>
<td>11,0 ± 2,0</td>
<td>13,2 ± 2,2</td>
</tr>
<tr>
<td></td>
<td>11,5 ± 1,9</td>
<td>ns</td>
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</table>

**Discussion**

An acute effect of one application of TENS applied simultaneously to the tibial nerve and to S2-S4 foramina on bladder function using urodynamic parameters was demonstrated in patients with the OAB syndrome. Whether the findings represent the clinical effect of TENS in patients with complaints of OAB symptoms, needs to be clarified.

It appeared to be possible to combine TENS applied simultaneously to the tibial nerve and to S2-S4 foramina and to detect sensitive urodynamic parameters as First Sensation of bladder Filling (FSF), bladder capacity, and peak flow.
We believe that TENS facilitates the voiding process by lowering the urethral pressure. In this population with symptoms of the OAB syndrome, a high concurrence of overactivity of the resttone of the pelvic floor was found. Because the urethral sphincter is an integral part of the pelvic floor, we believe the urethral pressure is high, as a result of this phenomenon. No reference of this in the literature could be found and this consistent phenomenon is the focus of a present study in our department.

In the literature, sham TENS did not alter the outcome measures. A bias in this study may be that sham TENS was not performed. However, the relevance of sham TENS seems debatable, because patients are aware when no stimulation is given.

By comparing the cystometric capacity and the micturition volume, there seems to be a relevant PVR. However, this is due to the fact that some patients were unable to void completely or even to void at all during urodynamics, because they were asked to refrain from straining or inhibited due to the urodynamic setting (15). Ultrasonography of the bladder prior to urodynamic investigation showed no relevant PVR in the studied patient population studied.

With respect to the stimulation parameters for TENS, as yet there is no consensus regarding optimal stimulation parameters for percutaneous stimulation in patients with overactive bladder (16). As far as it is known, studies systematically evaluating the optimal settings of electrostimulation are lacking. Settings used in literature are mainly empirical. The most commonly used settings of TENS are a burst of 2 Hz with pulse duration of 200 μsec and a frequency of 20 HZ (Melzack and Wall). These settings were used for pain control by TENS. We used the same empirical parameters in OAB.

The mechanisms responsible for the beneficial effect of TENS in the treatment of bladder dysfunction remain unclear. One specific hypothesis is that detrusor overactivity is known to be associated with female stress urinary incontinence as a result of pelvic floor relaxation. This may suggest that afferent nerve activity from the pelvic floor and urethra is involved in detrusor inhibition during bladder filling.

TENS applied only to the sacral dermatomes had a minimal effect on urodynamic data (17). Our experience supports this conclusion.

PTNS has a clear carry-over effect: 30 minutes of stimulation induces a lasting beneficial effect. Cat experiments, with a 5-minute stimulation of afferent nerves resulted in more
than 1 hour of bladder inhibition (18). SNS has been applied in various conditions refractory to conservative approaches. The success rates are usually in the range of 55-80% and are probably limited by the fact that no variables predictive of outcome have been identified. It is now generally accepted that SNS works via stimulation of the afferent rather than efferent nerves and effects at the level of the supraspinal nervous system (7, 19). Parallel to the gate control theory for pain, it may also be suggested that stimulation of large somatic fibers could modulate or inhibit the thinner afferent A-delta or C fibers, thus decreasing the perception of urgency.

In the experience of our institute, the treatment with TENS applied simultaneously to the tibial nerve and to S2-S4 foramina was effective.

**Conclusion:**

In the present study an acute effect of one application of TENS applied simultaneously to the tibial nerve and to S2-S4 foramina on bladder function using urodynamic parameters in patients with the OAB syndrome was demonstrated. Whether the findings represent the clinical effect of TENS in patients with complaints of OAB symptoms, needs to be clarified.
References


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