Improvement of storage function of the complicated bladder with semi-conditional dorsal penile nerve stimulation in spinal cord injury

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Abstract

The aim of this study was to investigate the effect of semi-conditional DPN stimulation for complicated bladder in patient with spinal cord injury.

DPN stimulation was applied to six male patients in semi-conditional pattern, which it is started as the subject sense the bladder contraction, and continued in cyclic manner by preset program, 1-3 times daily for two to four weeks. This method allows the bladder to distend, with low pressure.

The infused volume of saline at the 1st reflex contraction, the maximal volume which could be attained by DPN stimulation and the clinical bladder capacity which measured as voiding volume by reflex voiding and/or CIC were significantly increased after treatment.

The compliance of the bladder was also improved after treatment. Four cases of vesicoureteral reflux were disappeared, and degree of deformation of the bladder wall was improved after treatment.

Electrical stimulation of afferent pathway to sacral cord has definite benefits for control in terms of timing. Adjuvant use of semi-conditional DPN stimulation with conventional treatment can avoid unnecessary emptying/leakage. This method allows the bladder to distend, with low pressure by the physiological filling of urine, and helps to improve compliance and capacity of the bladder.

Introduction

The goal of management of neurogenic bladder in patients with spinal cord injury is the preservation of renal function and maintenance of urinary continence for a better social integration. It is very important to prevent the bladder from low compliance because it causes deterioration of renal function as well as causing hydronephrosis. Bladder hyperreflexia correlated closely with low compliance and bladder wall deformity. Methods for the treatment for hyper-reflexic bladder with low compliance are variable, including either the oral or intravesical administration of anticholinergics. Pharmacological treatment with anticholinergic agents helps to prevent incontinence, but cannot counteract the activity of the bladder in some cases, and some patients do not tolerate the side effects of the drugs.

Another management option for bladder hyperreflexia is electrical stimulation to sacral afferent neural pathway [1]. The stimulation effectively inhibited unwanted detrusor contractions and increased cystometric capacity in SCI patients. This method showed favorable results not only in the laboratory, but also after discharge to home [2]. An immediate inhibition of the reflex contraction of the bladder, using dorsal penile nerve (DPN) stimulation, has definite benefits for control in terms of timing. The patient can suppress the unwanted bladder contraction voluntarily, and distend the bladder, with low pressure by the physiological filling of urine, if the patients can feel the bladder contraction. DPN stimulation can be applied conditionally, when the intravesical pressure begins to rise, at the beginning of a hyper-reflexic contraction [3].

The aims of this study was to investigate the effect of semi-conditional DPN stimulation for improvement of the storage function of the bladder and upper urinary tract damage in patient with spinal cord injury.

Methods

2.1 Subjects

Six male spinal cord injury patients with low compliance bladder were studied (table 1.) Three tetraplegics and three paraplegics with thoracic SCI were participated. The patients had neurogenic dysfunction of the lower urinary tract, for which conventional measures had failed. All the subjects managed their bladder with intermittent catheterization (IC) every 4 to
6 hours and/or reflex voiding. They complained of frequent leakage between the catheterization, although he had been taking anticholinergics. All of them could feel the sensation of bladder contraction just before urination, which was so urgent that he could not maintain continence. They showed moderate to severe grade of trabeculation in bladder wall on radiography, four of them had grade II to III vesicoureteral reflux.

Table 1: Subject characteristics

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Level</th>
<th>ASIA</th>
<th>Duration(m)</th>
<th>Voiding method</th>
<th>Medication</th>
<th>Duration of Treatment(d)</th>
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<tr>
<td>A</td>
<td>46</td>
<td>M</td>
<td>T9</td>
<td>A</td>
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<td>P&amp;C, CIC</td>
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<tr>
<td>B</td>
<td>59</td>
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<tr>
<td>C</td>
<td>49</td>
<td>M</td>
<td>T10</td>
<td>C</td>
<td>144</td>
<td>CIC</td>
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</tr>
<tr>
<td>D</td>
<td>40</td>
<td>M</td>
<td>C5</td>
<td>A</td>
<td>50</td>
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<tr>
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<td>M</td>
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<tr>
<td>F</td>
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<td>M</td>
<td>C5</td>
<td>B</td>
<td>150</td>
<td>P&amp;C</td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

Mean 44.50 76.83 23.00

2.2 Determination of Stimulation Parameter

Electrical stimulation was applied using a portable neuromuscular stimulator. The DPN was stimulated using surface electrodes with 1cm diameters. The cathode and anode were placed, proximally and distally, respectively, on the dorsum of the penile shaft. The stimulation parameters used were biphasic rectangular pulses of 25Hz frequency, with a 250µsec pulse width. The intensity of the stimulation used was twice that of the pudendo-anal reflex threshold. Standard water cystometry was performed to identify the suppressive effect of the DPN stimulation to the reflex contraction, and the adequate ‘on-off’ duration setting for the cyclic stimulation.

A DPN stimulation of 50 seconds was repeated on every reflex contraction during the cystometry. The stimulation was applied after the detrusor contraction was identified, by observing 2 or more typical oscillations in the detrusor pressure curve. The test protocol was designed to stop infusion if: (1) the electric stimulation did not suppress the reflex contraction; (2) the infused volume reached 450ml; (3) the systolic blood pressure (SBP) rose 40mmHg above the baseline; or (4) if the subject could not tolerate the test. The ‘off’ duration of the stimulator was determined as when the stimulation started before the subsequent reflex contraction, according to the findings of the cystometry with DPN stimulation.

Therapeutic neuromodulation was applied as semi-conditional pattern, which it is started as the subject sense the bladder contraction, and continued in cyclic manner by preset program until the subject felt any discomfort or fullness.

2.3 Treatment and evaluation

The semi-conditional, cyclic DPN stimulation was used in the patient’s home, 1 – 3 times daily. Before and after two to four weeks of treatment, standard water cystometry with semi-conditional DPN stimulation was performed. Infusion volume at the 1st contraction and maximal volume which could be attained by DPN stimulation were compared. Clinical bladder capacity, which measured as voiding volume by reflex voiding and/or CIC was recorded using voiding diary. Severity of vesicoureteral reflex and trabeculation was evaluated on radiography.

3 Results

The infused volume of saline at the 1st reflex contraction increased from 45.17 ± 23.84 mL to 165.5 ± 156.5 mL after treatment (Fig. 1-A). The maximal volume which could be attained by neuromodulation also increased from 203.67 ± 77.55 mL to 359.50 ± 70.43 mL after treatment (Fig. 1-B). The clinical bladder capacity was measured by reflex voiding and/or CIC.
capacity also significantly increased from $201.67 \pm 106.10$ mL to $383.33 \pm 51.64$ mL after treatment (Fig. 1-C). The compliance of the bladder before treatment was $3.30 \pm 1.89$ mL/cmH$_2$O, and improved to $11.26 \pm 9.18$ mL/cmH$_2$O after treatment (Figure 2.) There were four subjects who showed grade II to III vesicoureteral reflux on radiography before treatment. However no subjects showed vesicoureteral reflux after treatment. Severity of the bladder wall deformation was also improved in 5 cases after treatment (Table 2.).

**Figure 2:** The effect of semiconditional DPN stimulation to the compliance of the bladder

<table>
<thead>
<tr>
<th>Subjects</th>
<th>VU reflux</th>
<th>Trabeculation/Diverticulum</th>
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<tbody>
<tr>
<td></td>
<td>pre post</td>
<td>pre post</td>
</tr>
<tr>
<td>A</td>
<td>GIII, R</td>
<td>0  2</td>
</tr>
<tr>
<td>B</td>
<td>0  0</td>
<td>4  3</td>
</tr>
<tr>
<td>C</td>
<td>GIII, L</td>
<td>0  4</td>
</tr>
<tr>
<td>D</td>
<td>GIII, L</td>
<td>0  2</td>
</tr>
<tr>
<td>E</td>
<td>0  0</td>
<td>3  1</td>
</tr>
<tr>
<td>F</td>
<td>GIII, L</td>
<td>0  4</td>
</tr>
</tbody>
</table>

**Table 2:** Changes in severity of vesicoureteral reflux and bladder wall deformation

4 Discussion and Conclusions

The stimulation of large sacral afferents has been shown to produce acute inhibition of detrusor hyper-reflexia caused by pudendal-pelvic spinal reflex pathways. The electrical stimulation of the sacral afferent pathway in spinally injured patients has the potential to suppress the detrusor hyper-reflexia, which if untreated may contribute to incontinence, vesicoureteric reflux and renal failure.

The stimulation effectively inhibited unwanted detrusor contractions, and increased the cystometric capacity of SCI patients. This method showed favorable results, not only in the laboratory, but also following patient discharge. We reported a case involving the useful application of the self-controlled stimulation of the dorsal penile nerve (DPN) for bladder hyper-reflexia in SCI. When the patient used home stimulation, the rate of leakage between catheterizations decreased, and the catheterized volume increased significantly. This technique has the potential to minimize the fluid intake restriction, avoid unnecessary catheterization and reduce the need for urine collection devices.

Although the inhibitory function of sacral afferent pathway stimulation to the hyper-reflexic bladder is well known, individually designed test protocols, identifying the results of specific goals, are necessary. Poor bladder compliance is closely correlated with bladder hyper-reflexia, and is one of the main causes of upper urinary tract damage. If the patient can feel the sensation of bladder contraction, conditional DPN stimulation can be used as a useful, easy and safe [4] technique to improve the condition, through the suppression of unwanted bladder contractions.

These reports demonstrate the feasibility of using conditional DPN stimulation, for the improvement of bladder compliance and upper urinary tract damage.

Electrical stimulation of afferent pathway to sacral cord has definite benefits for control in terms of timing. Adjuvant use of semiconditional DPN stimulation with conventional management methods can avoid unnecessary emptying/leakage. This method allows the bladder to distend, with low pressure by the physiological filling of urine, and help to maintain/improve compliance and capacity of the bladder.

References


