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*Original Article*

# Effects of electroacupuncture combined with bladder training on the bladder function of patients with neurogenic bladder after spinal cord injury

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**Abstract:** Neurogenic bladder is a common complication of spinal cord injury and results in urinary bladder dysfunction through lost control of micturition, or urination. Although several treatment options exist, the efficacies of many of these treatments are unknown. In particular, electroacupuncture and bladder training have had some success as individual treatments. The aim of this study was to explore effects of electroacupuncture combined with bladder training on bladder function of patients with neurogenic bladder after spinal cord injury (SCI) above the sacral segment. Forty-two patients with neurogenic bladder after SCI were evenly divided into two groups (n=21) and given only bladder function training (control group) or electroacupuncture combined with bladder function training (treatment group). Urodynamic changes, IPSS score, and therapeutic efficacy were compared between groups pre- and post-treatment. After either treatment, patients had higher bladder volume and bladder compliance, but lower residual urine volume, bladder pressure, rectal pressure, and detrusor pressure, compared to pre-treatment ($P$<0.05). Compared to controls, treatment group patients had significantly increased bladder volume and bladder compliance, but significantly decreased residual urine volume, bladder pressure, rectal pressure, and detrusor pressure ($P$<0.05). Treatment group patients had lower IPSS scores post-treatment ($P$<0.05) and better therapeutic efficacy ($P$<0.05) than control group patients. Altogether, our results suggest that electroacupuncture combined with bladder function training can clinically improve bladder function of patients with neurogenic bladder after SCI above the sacral segment.

**Keywords:** Bladder function, spinal cord injury, neurogenic bladder, electroacupuncture

## Introduction

Neurogenic bladder is dysfunction of the urinary bladder due to injury of the central nervous system or peripheral nerves involved in the control of micturition, or urination [1]. Clinically, neurogenic bladder is one of the common complications caused by spinal cord injury (SCI), which refers to damage to spinal cord structure and function. SCI can be due to various causes and contributes to motor, sensory, and autonomic dysfunction below the level of injury [2]. In current clinical practice, the treatment for neurogenic bladder tends to adopt surgical methods or non-surgical methods involving intermittent catheterization, continuous drainage, drug treatment, and bladder training and expansion, although the efficacy of these methods is unreliable [3]. Therefore, we asked whether bladder function could be improved by electroacupuncture combined with bladder training for patients with neurogenic bladder after spinal cord injury above the sacral segment.

## Materials and methods

### *Subjects*

Subjects included 42 patients admitted to Changhai Hospital, Second Military Medical University Shanghai, from January 2013 to December 2013 with neurogenic bladder after SCI above the sacral segments. All patients had a history of SCI and underwent definitive diagnosis with CT scan. Clinical manifestations were urinary frequency, urinary urgency, urinary incontinence, or desire to urinate but difficulty

**Table 1.** International Prostate Symptom Score (IPSS) questions and scored answers

| In the past month, have you had the following symptoms? | In 5 times | | | | | |
|---|---|---|---|---|---|---|
| | Not at all | Less than 1 in 5 times | Less than half the time | About half the time | More than half the time | Almost always |
| 1. How often have you had the sensation of not emptying your bladder? | 0 | 1 | 2 | 3 | 4 | 5 |
| 2. How often have you had to urinate every two hours or less? | 0 | 1 | 2 | 3 | 4 | 5 |
| 3. How often have you stopped and started again several times when urinating? | 0 | 1 | 2 | 3 | 4 | 5 |
| 4. How often have you found it difficult to postpone urination? | 0 | 1 | 2 | 3 | 4 | 5 |
| 5. How often have you had a weak urinary stream? | 0 | 1 | 2 | 3 | 4 | 5 |
| 6. How often have you had to strain to start urination? | 0 | 1 | 2 | 3 | 4 | 5 |
| 7. How many times did you typically get up at night to urinate? | None | 1 | 2 | 3 | 4 | 5 |
| | 0 | 1 | 2 | 3 | 4 | 5 |

controlling urination. Urodynamic findings showed varying degrees of neurogenic bladder dysfunction and all B-mode ultrasound examinations suggested reduced bladder capacity and varying residual bladder volumes. All possible cases of urinary stones, hydronephrosis, or infection were excluded. According to chronological order in which patients were included, they were grouped using a random number table for treatment or control groups (n=21). The treatment group included 13 males and 8 females (age range=20-63 years, mean=37.2±8.3 years; duration of sickness=0.5-6 months, mean=2.4±1.3 months). The control group included 14 males and 7 females (age range=21-62 years, mean=37.5±8.6 years; duration of sickness=1-6 months, mean=2.6 ±1.5 months). Both groups had comparable gender, age, and duration of sickness that did not statistically differ ($P>0.05$). The study was approved by the Ethics Committee of Changhai Hospital, Second Military Medical University.

*Acupuncture*

Patients were put in the lithotomy position with their hips and knees bent. Then, 2 cun acupuncture needles were used to straight pierce acupoints points Guanyuan (Ren4) and Zhongji (Ren3). Needles were connected to an Acupoint nerve stimulator (HANS, Beijing Hua Wei Industrial Development Company) and stimulated at 102 Hz at 20 mA intensity. Electrical stimulation was stopped when urine leakage occurred three times or when no urination occurred after perfusion of 300 mL of normal saline. Treatment included four courses, two weeks for each course; each course involved daily stimulation five times per week, for a total of ten stimulations in two weeks.

*Bladder training*

The goals of bladder training were to recover functions of detrusor muscle and urethral sphincter (i.e., contraction, relaxation, and synergistic movement) to restore normal bladder capacity and to avoid urinary incontinence and uroschesis. Training was done in three steps: 1) We established a system for drinking a fixed amount of water at a fixed interval. From the time patients awoke, they drank about 250 mL of water once every 2 hours until 20:00. In the interval from 20:00 to 6:00 the next day, patients drank no water. Total water was limited to about 2000 mL per patient. 2) We established a system for timed voiding. Patients urinated once every 4 hours and once before going to bed. When urination by stimulation failed, extrusion was performed by extending the hypogastric region downward in a gentle-to-heavy manner until urine was discharged to promote bladder emptying and reduce residual urine volume. 3) We performed intermittent catheterization. After SCI, early voiding dysfunction manifested mainly as uroschesis, so retention catheterization was adopted. When patients' general condition was stable and urinary tract infections were absent or controlled, intermittent catheterization was performed as soon as possible. From then on, urethral catheterization was done once every 4-6 hours.

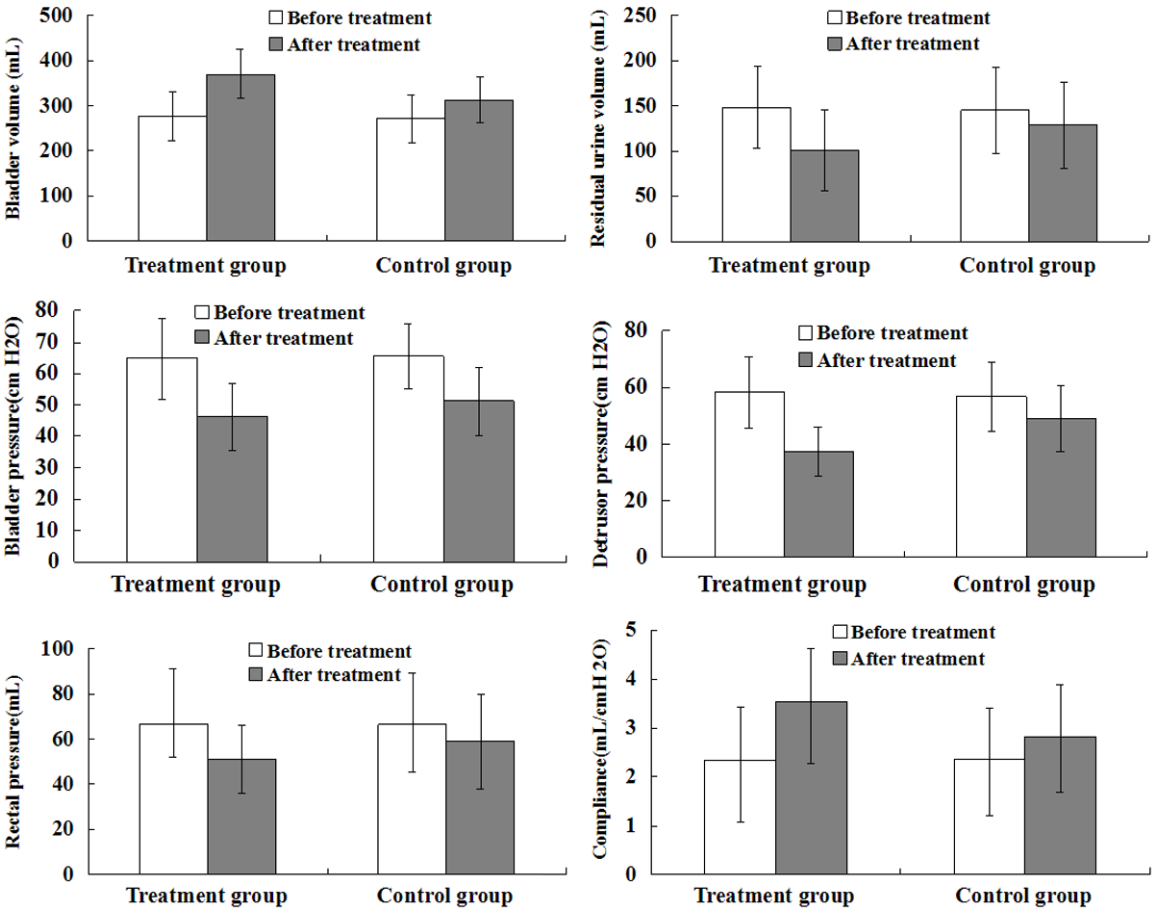


**Figure 1.** Urodynamic bladder changes pre- and post-treatment in treatment and control groups.

Before every catheterization, bladder training was performed. During two catheterization times, if urine could be discharged automatically and reached over 200 mL in volume or if residual urine volume could be reduced to about 200 mL by extrusion, then catheterization was done once every 8 hours. Afterwards, according to how bladder function recovered, the number of catheterization times was reduced and catheterization was stopped when residual urine volume was less than 100 mL. Treatment included a total of four courses, each lasting 15 days.

*Urodynamic measurement*

Uroflowmeter (Laborie Medical Technologies, Inc.) measurements of urodynamic parameters of pre- and post-treatment subjects were measured by the same physician according to standard methods recommended by the International Continence Society [4]. Urodynamic parameters included bladder capacity, residual urine volume, bladder pressure, rectal pressure, detrusor pressure, and bladder compliance, which were measured multiple times to calculate mean values.

*International Prostate Symptom Score (IPSS)*

IPSS consisted of seven questions that were measured pre- and post-treatment (**Table 1**). Answers were assigned points from 0 to 5, for a total score of 0 to 35.

*Efficacy criteria*

Patients were scored for efficacy as follows: cure=normal urinary function, residual urine volume <100 mL, smooth urination, and almost no effect on life and work; excellent=recovered but not complete urinary function and residual urine volume >100 mL; improvement=partly recovered urinary function and residual urine volume >200 mL; failure=no evident change in urinary function after treatment and still requires retention catheterization.

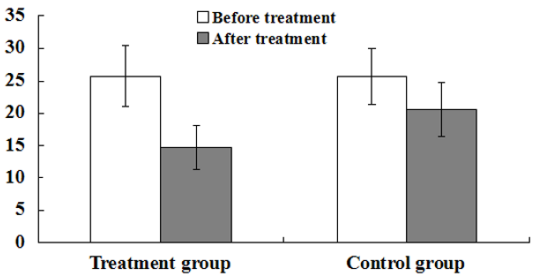


**Figure 2.** IPSS scores pre- and post-treatment in treatment and control groups.

*Statistical analysis*

SPSS software (Version 17.0 SPSS, Chicago, IL, USA) was used to analyze data, which was expressed as mean ± standard deviation ($\bar{x}\pm s$). Analysis of variance of repeated measurement data compared the differences among patients within each group and between groups in terms of urodynamic parameters and IPSS pre- and post-treatment. Wilcoxon rank sum test compared the therapeutic efficacy of both groups. Hypothesis tests were two-sided test ($\alpha$=0.05), and $P$<0.05 was considered statistically significant.

## Results

*Urodynamic changes pre- and post-treatment*

Post-treatment bladder capacity and compliance in both groups were significantly higher than pre-treatment values, while residual urine volume, bladder pressure, rectal pressure, and detrusor pressure were significantly lower than pre-treatment values ($P$<0.05) (**Figure 1**). Compared with control group, the treatment group had significantly increased bladder capacity and compliance and significantly reduced residual urine volume, bladder pressure, rectal pressure, and detrusor pressure ($P$<0.05).

*IPSS values pre- and post-treatment*

Pre-treatment IPSS values of treatment and control groups were 25.7±4.7 and 25.6±4.3, respectively; post-treatment, IPSS values of treatment and control groups were 14.8±3.4 and 20.6±4.1, respectively (**Figure 2**). Therefore, IPSS values of both groups were significantly lower post-treatment than pre-treatment ($P$<0.05), and treatment group scores were significantly lower than control group scores ($P$<0.05).

*Comparison of therapeutic efficacies*

Total efficacy rate in the treatment group was 90.5% (19/21) and in the control group was 76.2% (16/21), a difference that was significant ($Z$=2.022, $P$=0.043) (**Table 2**).

## Discussion

The spinal cord is the primary reflex center for micturition, as it controls functions of the detrusor muscle and external urethral sphincter. It is also the common pathway that transmits sensory impulses from the bladder and urethra to the ascending and descending nerve fibers [5]. SPI damages the primary micturition center or its neural pathways, causing bladder and urinary tract dysfunction [6]. SPI also inevitably affects conduction pathways of ascending and descending nerve fibers and coordination between various centers [7]. When a lesion occurs above the sacral segment of the spinal cord, the micturition center remains intact; however, control by the higher micturition center is lost, which causes detrusor hyperreflexia and reflex voiding [2].

Clinical studies have shown that electroacupuncture can achieve reflex regulation of the corresponding nerve cell functions of the brain and spinal cord, relieve external urethral sphincter spasms, and coordinate functions of internal and external sphincters, thus promoting renal and urinary function, bladder movement, and contraction and relaxation of the urethral sphincter [9]. Traditional Chinese medicine believes that the Ren meridian is “the sea of yin meridians” that dominates all yin meridians. Guanyuan (Ren4) and Zhongji (Ren3) are key acupoints of the Ren meridian, where Zhongji (Ren3) is a Front-Mu point of the bladder and Guanyuan (Ren4) is a key point for strengthening kidney yang. The combination of both points with electrical stimulation can supplement qi, tonify kidneys, and induce astringency, thus improving bladder function [10]. Cheng *et al.* observed that acupuncture at acupoints including Zhongji (Ren3), Guanyuan (Ren4), and Ciliao (BL 32) could significantly shorten the time needed to balance neurogenic bladder, improve incontinence caused by detru-

**Table 2.** Therapeutic efficacy in treatment and control groups [*n* (%)]

| Group | *n* | Cure | Excellent | Improvement | Failure |
|---|---|---|---|---|---|
| Treatment | 21 | 6 (28.6) | 10 (47.6) | 3 (14.3) | 2 (9.5) |
| Control | 21 | 3 (14.3) | 6 (28.6) | 7 (33.3) | 5 (23.8) |
| Total | 42 | 9 (21.4) | 16 (38.1) | 10 (23.8) | 7 (16.7) |

$Z$=2.022, $P$=0.043.

sor hyperreflexia, and increase bladder capacity in SCI patients [8].

Bladder training mainly adopts effective abdominal extrusion to recover urine emptying and holding capacity to partly recover patients' urinary function and reduce residual urine volume. Our results show that treatment with both electroacupuncture and bladder function training significantly increases bladder capacity and compliance and significantly decreases residual urine volume, bladder pressure, rectal pressure, detrusor pressure, and IPSS. Further, patients that underwent this treatment had improved therapeutic efficacy. In summary, this study reveals that combined electroacupuncture with bladder training can induce rhythmic contraction and relaxation of detrusor muscle and internal bladder sphincter, promote the formation of micturition reflex, improve bladder function, and reduce urinary tract symptoms. Because the treatment induces quick results, is relatively easy, and has excellent efficacy, it is of high clinical value.

## Disclosure of conflict of interest

None.

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