Effect of sacral neuromodulation in patients with neurogenic bladder

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Abstract

Background: Sacral neuromodulation (SNM) is widely used in patients with non-neurogenic overactive bladder and urinary retention but has only been applied recently for the management of the neurogenic bladder, and data are still scarce.

Methods: This was a case series of patients who met the diagnosis of neurogenic bladder and received SNM between January 2016 and April 2019. Each participant received SNM. The evaluation of the participants' quality of life and urination diary (bladder symptom tracking form) included urine leaks, if urine pads need to be changed, urgent urination (0-5 points), urinary catheterization, and urinary output. The participants' expected values were analyzed. An effect >50% was considered effective.

Results: All participants complied with the preoperative perineal floor exercise training. Among the 14 participants who underwent phase I SNM, one had no response at all and was excluded. After permanent electrode implantation, the urine output of one participant was similar to that of before surgery, and one participant had an incision infection, and the electrode was eventually removed. The postoperative follow-up after stage II SNM was 7.5±2.1 (range, 5-12) months. All 11 patients showed significant improvements in numbers of urination, urgency score, residual volume, and urination volume. The postoperative NEWS pain score was 1.6±0.9.

Conclusions: Two-stage SNM can achieve satisfactory results in patients with neurogenic bladder. The key to success might lie in the correct and effective nursing and guidance throughout the perioperative management.

Introduction

Neuro-urologic symptoms are common in patients with neurologic conditions, such as spinal cord injury, stroke, and multiple sclerosis (MS), with incidence varying by neurologic condition [1]. Neurogenic bladder is a lower urinary tract dysfunction caused by a disorder of the neural control mechanism and can only be diagnosed in the presence of neuropathy [1]. Its prevalence is 57%-83% after stroke (with spontaneous recovery at 6 months in 71%-80% of the patients), 30%-70% in Parkinson disease, 38%-60% in traumatic brain injury, 83%-96% in cases of lesions or disease of the spinal cord, and 10%-75% multiple sclerosis [1]. The causes of neurogenic bladder include lesions (spinal cord or pelvic nerves) and dysfunction in the nervous system controlling the lower urinary tract as a result of stroke, brain tumor, nerve injuries, or another neurological condition. The types of neurogenic bladder include detrusor overactivity and underactivity (overactive and underactive bladder) and detrusor sphincter dyssynergia (DSD) [1, 2].

If the neurogenic bladder is not managed in time, urinary tract infections can occur [1, 2]. Urinary stones can occur in 10%-15% of patients, and the incidence of vesicoureteral reflux can reach 10%-40% [1, 3]. In addition, it can cause a variety of complications, the most serious of which were upper urinary tract damage and renal failure [4]. At the same time, the neurogenic bladder has various causes and may have different clinical manifestations, complicating its management. The management of a neurogenic

bladder includes behavioral therapy [5], surgery (such as transurethral resection of the external urinary sphincter, urethral stents, bladder augmentation, and artificial sphincter) [1-3, 6], interventional therapy (such as intravesical electrostimulation, sacral rhizotomy and electrostimulation, and tibial nerve stimulation) [6-9], and medication (such as anticholinergic drugs, α-blockers, mirabegron, and desmopressin) [1-3, 10, 11].

Sacral neuromodulation (SNM) is an intervention technique by which continuous low-frequency electrical pulses stimulate specific sacral nerves to stimulate or inhibit neural pathways and regulate sacral reflex by the placement of stimulating electrodes in the sacral foramen (usually the third sacral foramen) [12]. This neuromodulation technique affects and regulates the function of target organs of the sacral nerve (such as the bladder, urethra/anal sphincter, pelvic floor, etc.) [12]. SNM is widely used in patients with non-neurogenic overactive bladder and urinary retention but has only be applied recently for the management of the neurogenic bladder [13].

Therefore, the present study aimed to explore the effect of sacral neuromodulation in the neurogenic bladder and during follow-up. The results could provide some basis for its use in the management of patients with neurogenic bladder.

Methods

Study design and participants

In January 2016, the First Affiliated Hospital of Zhejiang University School of Medicine (tertiary hospital) introduced the Medtronic neuromodulation technique for clinical use. This was a case series of patients who met the diagnosis of neurogenic bladder and received SNM between January 2016 and April 2019. The study was approved by the ethics committee of the First Affiliated Hospital of Zhejiang University School of Medicine. The participants provided a signed informed consent form.

The inclusion criteria were: 1) diagnosis of neurogenic bladder by urodynamic imaging examination [1]; and 2) willing to participate in this study.

Perioperative management

The participants were encouraged to perform pelvic floor muscle training exercises before surgery through continuous contraction of the pelvic floor muscles (anus levator movement) for 2-6 s, followed by relaxation and rest for 2-s, repeated 10-15 times, 3-8 times every day.

Detailed steps of SNM

The prone position was taken, and the lower abdomen and the calves were elevated to ensure that the toes were suspended. The body surface was marked with bilateral S3 sacral nerve holes, and the needlepoint was about 2 cm above the marked point. The puncture needle pointed to the tail at a 60-degree angle and was pushed into the S3 sacral nerve hole perpendicular to the sacrum surface under x-

ray radiography. The temporary stimulator was connected. The tested pulse width was 150-300 μs (conventional pulse width was 210 μs), the frequency was 9-40 Hz (the initial setting was 14 Hz), and the voltage was 0.5-5 V (ideally no more than 2 V). The motor (plantar flexion of the big toe) and sensory responses (rectal tractive feeling, extending forward to the scrotum or labia) of the S3 sacral nerve of the patient were tested. In case of no response at S3, S4 was used. When a response was achieved, Agnail-like permanent electrodes were implanted, and the motor and sensory responses of each contact point were tested. A 3-cm incision above and outside the ipsilateral hip of the electrode was made for the tail of the barbed electrode. The percutaneous extension wire was connected, and placed into a subcutaneous tunnel and tested again.

The stimulator was turned on 24 h after surgery. The time for experiencing stimulation was 1-2 weeks. According to the results of the intraoperative test, four sets of parameters were set: 0- 3+, 1- 3+, 2- 0+, and 3- 0+. Each group of parameters was observed for at least 3 days.

If the patient's symptoms improved significantly, implantation of the sacral nerve stimulator was performed. The original hip incision was opened, and the percutaneous extension wire opposite to the incision was removed. The electrode was connected to the sacral nerve stimulator through an extension wire and implanted into a free subcutaneous space. The impedance was tested, and the incision was closed. The cycle mode was selected: 20 s on, 8 s off (SoftStart 4 s). The control variable method was used during program control, i.e., only one parameter was adjusted at a time. The goal for program control after the second implantation was optimal symptom improvement. The stimulation parameters were optimized as much as possible to extend the battery life. The peri- and postinterventional complications were classified according to the Clavien-Dindo classification [14].

Postoperative guidance

During phase I SNM, the participants were asked to cooperate with the professionals to set specific points according to the response of the intraoperative test the next day after surgery, that was, to set the contact combination (four combinations: 0 negative and 3 positives, 1 negative and 3 positives, 2 negatives and 0 positive, 3 negatives and 0 positive) and to adjust the voltage, pulse width, and frequency to achieve the optimal stimulation.

For phase II SNM, on the first day after surgery, the participants underwent voltage regulation, replacement group, switch stimulator, and how to recognize the numbers and symbols on the remote control. The participants continued their urination diary and were followed 3-6 times. The postoperative-related data (urinary diary, personal emotion, urodynamic monitoring, etc.) and collection of data directly related to the treatment are the accuracy of ultimate success or failure [15]. The treatment and follow-up plan was timely adjusted with the evolution of the participants' condition. Each follow-up included a physical examination, a urinary diary, program-controlled stimulation parameter detection and/or adjustment, X-ray of the sacrococcygeal region, and X-ray in the lateral position.

The possible complications related to surgery included pain in electrode and stimulator sites, electrode displacement, injury, and infection [16].

Data collection

The evaluation of the participants' quality of life and urination diary (bladder symptom tracking form) included urine leaks, if urine pads need to be changed, urgent urination (0-5 points), urinary catheterization, and urinary output.

Evaluation of the participants' expected ideal and expected values

The participants' expected values were analyzed. The effect depended to a large extent on the participants' expectations and compliance with the treatment. An effect >50% was considered effective [17].

Statistical analysis

SPSS 22 (IBM, Armonk, NY, USA) was used to process the data. Continuous data were tested for normal distribution using the Kolmogorov-Smirnov test, were presented using means ± standard deviation, and were tested using the paired t-test. $P<0.05$ was considered statistically significant.

Results

Characteristics of the participants

Fourteen participants were enrolled, all with failure to conservative treatment, including 13 males and one female, with a mean age of 54.6±7.5 years (range, 43-70 years). Table 1 presents the characteristics of the participants. Nine participants had a history of transurethral resection of the prostate, four participants had a history of trauma, and one participant had a congenital neural foramen bifida at the third sacrum. Six participants had frequent micturition and urgent urination, two participants had urinary incontinence, and six participants had dysuria. Six participants were with intermittent urinary catheterization, two participants were with indwelling urinary catheterization, two participants were with cystostomy, and four participants used urinal pads. After the evaluation by the patients, the expected value of urination in six patients was 1/3-2/3, and the expected value of urination in eight patients was about 50%.

Phase I SNM

The 14 participants performed the preoperative training as required, with an average of 3.6 training sessions per day. No response at all could be elicited in the participant with cauda equina injury, and he was excluded. The remaining 13 participants had pelvic floor muscle-like movements or lower limb flexion movements after surgery. The six patients with constipation showed improved defecation and formed soft stools. The analysis and comparisons of the 13 patients before and after stage I SNM are

shown in Table 2. All patients showed significant improvements in numbers of urination, urgency score, residual volume, and urination volume. The stimulation combination points were 2 negatives and 0 positive in eight participants; 0 negative and 3 positives in five participants. All 13 participants were followed for 2 weeks.

Phase II SNM

Thirteen patients underwent stage II long-term SNM. The female patient discontinued treatment because the urination effect was the same as that before implantation. The treatment was terminated by the withdrawal of long-term electrode in the patient with congenital neural injury at the third sacrum due to weight loss and poor healing of the incision. The comparisons and analysis of the remaining 11 patients before experiential treatment and after long-term electrode implantation are shown in Table 3. All 11 patients showed significant improvements in numbers of urination, urgency score, residual volume, and urination volume.

Complications

The postoperative NEWS pain score was 1.6±0.9. There was one case of hip incision infection. The incision was filled with nano-silver ion dressing in consultation with the hospital wound and stoma group. Exudate gradually decreased. A 50-ml injection of albumin was given. Although being treated, the electrode was eventually removed due to the patient's significant weight loss, thin subcutaneous fat, and poor healing ability.

Discussion

SNM is widely used in patients with non-neurogenic overactive bladder and urinary retention but has only be applied recently for the management of the neurogenic bladder [13], and data are still scarce. Therefore, this study aimed to explore the effect of SNM in the neurogenic bladder and during follow-up. The results suggest that two-stage SNM can achieve satisfactory results in patients with neurogenic bladder. The key to success might lie in the correct and effective nursing and guidance throughout the perioperative management.

SNM is an exciting, clinically feasible, minimally invasive treatment technology that brings hope to patients with refractory urination disorders with failure to conventional treatments [18]. In the present study, 11 patients received long-term electrode implantation, and the improvements in numbers of urination, urgency score, residual volume, and urination volume were obvious. Those effects were consistent with the literature, but most of the available data are limited to patients with stroke, Parkinson's disease, multiple sclerosis, or spinal injury [13, 18]. In contrast, in the present study, the etiology of the neurogenic bladder was TURP in most patients, only four had trauma, and none had a stroke. According to the literature, the success of phase I is 50%-68%, and the technical success rate of implantation is 80%-92% [13, 19-23]. In the present study, the technical success rate was 100%, but one patient showed no responses, and one patient reported no changes in urinary symptoms, for a success

rate of 86%. Two studies reported that patients with neurogenic bladder achieved smaller improvements with SNM than those with non-neurogenic bladder [22, 23]. Another study of patients with neurogenic bladder from various etiologies showed that 43% of the patients could stop their anticholinergic medications after SNM and that 80% achieved complete continence [24]. This is supported by Chartier-Kastler [25] and SAchieferdecker et al. [26]. Lombardi et al. [27] performed SNM in 24 patients with spinal cord injury and reported improvements >50% in all 24 patients.

In the present study, no complications related to the SNM itself were reported. Only one patient had intractable wound infection and loss of weight that required removing the electrodes. Wound infection was also observed by Lombardi et al. [27] According to the available literature, SNM is safe [13]. The absolute contraindications are pregnancy because of the theoretical risk of labor induction [13]. In addition, head-only 1.5 T magnetic resonance imaging can be performed in patients who received the latest newer generation electrodes [28, 29].

The use of pelvic floor exercises for urinary control is a well-known management method, but it has limited efficacy in patients with neurogenic bladder [30]. Therefore, such exercises were combined with SNM and could have contributed to the relatively high success rate observed in the present study. Nevertheless, the lack of a control group without pelvic floor exercises precludes us from reaching any firm conclusion on this point.

This study has additional limitations. The sample size was limited and needs to be expanded in future studies. Second, the follow-up time was short, and long-term follow-up is required to demonstrate the reliability of the method. Third, most of the patients in the present study were thin and malnourished. Moreover, the technology is relatively expensive.

Conclusion

In conclusion, two-stage SNM can achieve satisfactory results in patients with neurogenic bladder. The key to success might lie in the correct and effective nursing and guidance throughout the perioperative management. Additional studies are necessary to confirm the results.

Declarations

Ethics approval and consent to participate: The study was approved by the ethics committee of the First Affiliated Hospital of Zhejiang University School of Medicine. The participants provided a signed informed consent form.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no conflict of interest.

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Authors' contributions: ZJH: substantially contributed to conception or design, drafted the manuscript for important content, critically revised the manuscript for important intellectual content, gave final approval. SWX: contributed to acquisition, analysis, or interpretation of data.

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Tables

Table 1. Characteristics of the participants

Characteristics	Values
Sex, n (%)	
Male	13 (92.9)
Female	1 (7.1)
Age (years)	54.6±7.5
Etiology, n (%)	
History of transurethral resection of the prostate	9 (64.3)
Cauda equina injury due to falls	1 (7.1)
Congenital bifida of the third sacral neural foramen	1 (7.1)
Lumbar fracture due to car accident	2 (14.3)
Sacrococcyx injury	1 (7.1)
Degree, n (%)	
Cystostomy	2 (14.3)
Self-intermittent catheterization	6 (42.9)
Indwelling catheterization	2 (14.3)
Urinal pads	4 (28.6)
Combined with constipation, n (%)	6 (42.9)

Table 2. Comparison of the clinical data of the 13 patients who underwent phase I SNM

Variables	Before surgery	After phase I SNM	P
Number of urinations in 24 h	15.5±0.9	9.5±1.0	<0.001
Urgent urination score	4.5±0.5	1.4±0.3	<0.001
Residual urine volume (ml)	157±28	48±18	<0.001
Urination volume (ml)	66±12	175±10	<0.001

SNM: sacral neuromodulation

Table 3. Comparison of the clinical data of the 11 patients who completed phase II SNM

Variables	Before surgery	After phase II SNM	P
Number of urinations in 24 h	15.5±0.9	8.4±0.9	<0.001
Urgent urination score	4.5±0.5	1.4±0.3	<0.001
Residual urine volume (ml)	157±28	33±15	<0.001
Urination volume (ml)	66±12	176±11	<0.001

SNM: sacral neuromodulation