Control of Incontinence in Supra-sacral Spinal Cord Injury Patient using Cyclic Short-Duration Dorsal Penile Nerve Stimulation: A Case Report

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Abstract

This report describes the application of semiautomatic cyclic short-duration stimulation of the dorsal penile nerve for bladder hyper-reflexia in a SCI patient.

A 17-year-old male with T-11 complete paraplegia had a series of urodynamic studies (UDS) with stimulation. The first UDS was performed to identify the effect of conditional intermittent stimulation on each reflex contraction. All the contractions were suppressed effectively by stimulation. The duration of suppressive effect was longer than 45 seconds. The second UDS was performed to identify sustained suppression of bladder contraction by cyclic short-duration stimulation. Cyclic stimulation (30sec-on, 30sec-off) started when the first reflex contraction occurred and continued until the end of the test. Pdet remained suppressed by stimulation until 300ml of saline had been infused.

The subject used cyclic stimulation to control urgency-incontinence. He could start stimulation on sensation of bladder contraction and continued it as long as he needed. He could control incontinence up to 45 minutes after the first sensation of contraction.

Introduction/Background

At present the only neuroprosthesis for the neuropathic bladder produces emptying, by stimulating efferent nerves to the bladder. Storage, the other important function of the bladder, is achieved by rhizotomy, cutting the sensory roots during the implantation of electrodes. Rhizotomy has definite disadvantages such as loss of reflex erection, loss of sensation and irreversibility.1

Another possible method to improve urinary storage is electrical stimulation. This has been applied to SCI patients to inhibit hyper-reflexic contraction in two ways.2 One expects a therapeutic effect to continue after a treatment period,3 and the other expects an immediate, direct suppressive effect on hyper-reflexic contraction of the bladder. Some reports regarding therapeutic effects showed favorable results in urodynamic studies after four to sixteen weeks of stimulation,3, 5 but the rate of achievement of complete continence was less than 20%.

The other group of studies expecting a direct immediate effect of stimulation showed a consistent suppressive effect on provoked reflex contraction,6 and reported the optimal stimulation parameters.4 However there was no report of clinical trials using this technique.

There have been reports of prolonged suppression of hyper-reflexic contraction by continuous stimulation.2 Another report described effects of demand driven short duration stimulation of the dorsal penile nerve (DPN) to increase bladder capacity.2 Both techniques may be impractical to use in daily living, because of battery and adaptation issues.

This case report describes the application of semiautomatic cyclic short-duration dorsal penile nerve stimulation for bladder hyperreflexia in a patient with complete suprasacral SCI. The patient’s clinical presentation, urodynamic findings, and clinical findings with stimulation are presented.

Case Description

The patient was a 17-year-old male with T-11 complete paraplegia for 1 year after a motor vehicle accident, admitted to a SCI unit for study. At the time of the study, he managed his bladder with percussion and occasional intermittent catheterization (IC). He reported frequent leakage between reflex voidings, although he had been taking oxybutynin chloride 10mg per day for five months, and had to use a diaper at all times. He could feel the sensation of bladder contraction just before urination, but it was so urgent that he could not maintain continence.

Urodynamic study
The previous urodynamic study, which had been performed 2 months before this study, showed typical hyper-reflexic contractions of bladder when 70mL of saline was infused.

Saline was infused at a rate of 30mL/min until the first reflex contraction occurred and then at 10mL/min until the infused volume reached 450mL. The test protocol was also designed to stop infusion if 1) electrical stimulation did not suppress reflex contraction, 2) Pdet > 50cmH2O, or 3) the subject could not tolerate the test.

Electrical stimulation to suppress the reflex contraction was applied using a portable neuromuscular stimulation system. The DPN was stimulated using circular surface electrodes of 1cm diameter. The cathode was placed proximally and anode distally on the dorsum of the penile shaft 2 cm apart. Stimulation parameters were biphasic rectangular pulses of 25Hz frequency, 250μsec pulse width. Stimulation intensity was twice the threshold of the pudendo-anal reflex.

The first UDS was performed to identify the effect of conditional stimulation for one minute on each reflex contraction (fig 1 A). The first reflex contraction occurred when 55ml of saline had been infused, and was effectively suppressed by one minute stimulation. The second contraction followed 92 seconds after stopping stimulation. One-minute stimulations were repeated when each contraction occurred. All the contractions were suppressed effectively by stimulation. The duration of suppressive effect became shorter according to the increasing volume infused, but was longer than 45 seconds. He began to feel fullness when 280mL of saline had been infused. We emptied his bladder immediately.

The second UDS was performed to identify the possibility of sustained suppression of bladder contraction by cyclic short-duration stimulation(fig 1- B). Considered the findings of the first UDS, which showed that suppression lasted longer than 45 seconds after stopping stimulation, we set the program of stimulation to a “30sec on – 30sec off” cyclic mode. The cyclic stimulation started when the first reflex contraction occurred (135ml infused) and continued until the end of this UDS. Pdet remained suppressed at about 10 cmH2O until he gave a cough (300ml of saline infused). Pdet then increased to 20cmH2O, but still remained stable until an additional 50ml had been infused. Pdet with and without stimulation rose thereafter, and reached 50cmH2O when 400ml of saline had been infused. The patient reported fullness and the test was stopped.

The third UDS was performed to confirm hyper-reflex contraction without DPN stimulation (fig 1- C). The typical reflex contraction occurred when 125 ml of saline had been infused. Pdet rose to 55 cmH2O.

We suggested that he use cyclic DPN stimulation to control urgency-incontinence. He placed electrodes on the dorsum of the penis and the stimulator on his waist using a belt-clip. He could start stimulation on sensation of bladder contraction and continued it as long as he needed. He could control incontinence up to 45 minutes after sensation of bladder contraction. He also kept dry for 5 hours with stimulation while he slept.
Discussion

Stimulation of large sacral afferents has been shown to produce acute inhibition of detrusor hyperreflexia by pudendal-pelvic spinal reflex pathways. The immediate suppressive effects of stimulation on hyper-reflexia in SCI have been shown to be consistent and reliable.\(^2\)\(^,\)\(^6\) Hyper-reflexic contractions in suprasacral SCI were suppressed effectively by either electrical stimulation of the pudendal nerve or magnetic stimulation of the sacral roots.\(^6\)

There have been reports that prolonged suppression of hyper-reflexic contraction was achieved by continuous stimulation. Wheeler et al.\(^2\) reported that the cystometric bladder volume during DPN stimulation also increased in all six patients tested, by 27% to 150% of the pre-stimulation volume. Continuous stimulation may be limited by adaptation of neural pathways and/or the life of battery.

Some patients with spinal cord injury can feel the sensation of reflex bladder contraction. There has also been a report which described effects of demand driven short duration DPN stimulation to increase bladder capacity.\(^7\) That technique might be inconvenient to use in daily living, if it required too much attention to operate it.

The patient in this report could control incontinence using cyclic stimulation, even during high-level exercise activity. He reported minor technical problems such as arrangement of cables. He shaved his pubic hair but there still was difficulty in keeping the electrode attached for long periods.

This case report demonstrates the feasibility of using semiautomatically controlled dorsal penile nerve stimulation to inhibit hyper-reflexic contraction of the bladder in SCI patients, as an adjuvant method of incontinence management. Further development of electrodes and effective, efficient location of stimulation is needed.

References