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PATTERNED MUSCLE STIMULATION INHIBITION OF BLADDER URGENCY IN M.S.
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In multiple sclerosis bladder, urgency and incontinence with incomplete emptying are common. The neuro-muscular system loses coordination as the nerves decrease their strength of activation. Urodynamic studies disclose early bladder contractions. During voiding, these are not sustained and produce incomplete evacuation. The sympathetic – parasympathetic systems also demonstrate impaired sensory-motor coordination. Regional sympathetic systems up-regulate as somatic input decreases. Sympathetic detrusor afferents are activated by stretch receptors enter the spine at T10 to L2. Activation of large cutaneous and segmental muscle stretch sensory fibers activate local reflexes and inhibit micturition (guarding reflex). Repetitive activation of these somatic sensory nerves entering at the same level as the sympathetics, reduces the hyper-sensitivity of the sympathetic arm of the micturition reflex. Electrical stimulation of motor and cutaneous sensory input at T10 to L2 spinal root levels is shown in this study to inhibit overactive bladder of multiple sclerosis. **Methodology:** 13 patients with chronic progressive MS (6 female, 7 male) ages 28 to 59 all with lower extremity weakness and spasticity applied the repetitive stimulation for 20 min two to three times per week for four weeks. All had previously applied the same pattern of stimulation to the quadriceps and hamstrings without reduction of incontinence. All stimuli intensities produced abdominal and medial thigh muscle twitch. **Results:** Application of the same pattern of stimulation to the skin and muscles of the T10 to L2 dermatomes produced a dramatic reduction in urgency and incontinence in eleven of the 13 patients (5 female, 6 male). None noted discomfort from the stimulation, nor were there any undesired side effects. Quantified measures included # hrs. between urgency. (1.75 vs 4.5) Number of incontinent voids per 24hrs during the daytime (3.6 vs 0.8) and at night (1.4 vs 0.8). The volume of continent voids (small, med., large) also increased. **Additional Findings:** Of the six males with erectile dysfunction, five of them regained tumescence capability that lasted for many months after the program **Follow-up:** All patients slowly reverted back to pre treatment incontinence levels after four to six weeks without additional treatment. All were able to regain control within one or two sessions after resuming the above treatment. **Conclusions:** Surface patterned muscle stimulation applied to the T-10 to L-2 dermatomes and underlying muscles can reduce the incidence of urgency and incontinence in patients with chronic progressive MS. There are also very positive side effects such as reversal of erectile dysfunction in most of the affected males.

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Title (type in CAPITAL LETTERS, leave one blank line before the text):
CONDITIONAL NEUROMODULATION OF END-FILL HYPERREFLEXIA TO INCREASE BLADDER
CAPACITY IN SPINALLY INJURED PATIENTS

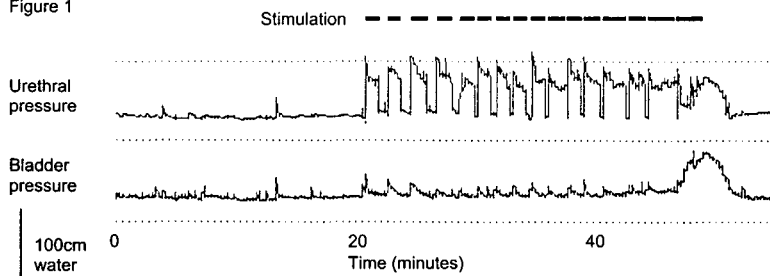
Aims of study: Stimulation of the Dorsal Penile (or Clitoral) nerve is known to suppress hyperreflexic bladder contractions in spinally injured patients(1). Such neuromodulation can be applied in several ways. Applied continuously, it increases bladder capacity in almost all cases(2). If applied at the start of a hyperreflexic contraction (conditionally), the strength of the contraction is markedly reduced. We are evaluating the use of neuromodulation via the posterior sacral roots to replace the need for posterior rhizotomy after the implantation of a Finetech-Brindley stimulator -

in this case a Sacral Posterior and Anterior Root Stimulator (SPARS) (3). The stimulation will initially be continuous, but we aim to develop an implanted device that detects the start of hyperreflexic contractions and applies neuromodulation conditionally. The aim of this study was to determine the effects of conditional and continuous neuromodulation during slow bladder filling.

Methods: Seven spinally injured patients were studied. They all had lesions above L1, and in three patients the lesion was incomplete. Anticholinergics were stopped at least four days before the test. The bladder was filled at 10ml/min and in all cases two standard cystometrograms were performed to establish the baseline capacity, using a 4 channel solid state pressure transducer (Gaeltech, UK) to measure bladder and urethral pressure. Two different protocols were used to compare the effects of continuous and conditional neuromodulation. In the first (protocol A), four or six cystometrograms were performed, with continuous and conditional neuromodulation during alternate fills. In the second (protocol B), a series of three cystometrograms was performed with conditional neuromodulation only, and on a different day the study was repeated using continuous neuromodulation only. In each protocol, a further control cystometrogram was performed at the end of the study. The neuromodulation in all cases was applied via skin electrodes to the dorsal penile nerve at a frequency of 15 pps and pulse width 200 μ s. The current was set at a level equal to twice the threshold for the pudendo-anal reflex (15 to 80 mA). In two patients we also examined the effects of conditional neuromodulation by stimulating the mixed sacral nerves using a Finetech-Brindley Sacral Nerve Root Stimulator Implant (figure 1). Conditional neuromodulation was triggered by a rise of 10cm in the bladder pressure trace, and lasted for one minute. Filling was stopped when there was urine flow per urethra or a rise in intravesical pressure of 35 cm H₂O.

Results: In each of the seven patients, the mean bladder capacity with conditional neuromodulation was greater than the initial controls. The increase ranged from 80 to 305ml (mean 170ml, standard deviation 95ml). It was significant (paired Student t test, $p < 0.01$). The bladder capacity in the final control cystometrogram was larger (mean increase 97ml, SD 103ml) than in the initial two control fills. In the four patients in protocol A, the means of both the conditional and continuous neuromodulation fills were increased over control, by a mean of 145ml (SD 107ml) and 98ml (SD 46ml) respectively.

Figure 1



Conclusions: This study has shown that both continuous and conditional neuromodulation through surface or implanted electrodes can significantly increase bladder capacity in spinally injured patients.

(1) *Experimental Physiology* (1999), 84; 149-160

(2) *Neurourology and Urodynamics* (1998), 17; 411-413

(3) *British Journal of Urology* (2000), *in press*