Peripheral Nerve Stimulation Therapy for Restoring Bladder Function in Persons with Spinal Cord Injury

Paul B. Yoo, Member, IEEE

Abstract—Posterior tibial nerve stimulation (PTNS) is an emerging technology that can potentially be used to restore bladder function in persons with spinal cord injury. However, the clinical use of this approach remains a significant challenge due to our limited understanding of the neural mechanisms. In this paper, we present recent experimental data that suggest optimum stimulation parameters for controlling bladder function.

I. INTRODUCTION

Restoring lower urinary tract function remains a significant challenge for individuals with chronic spinal cord injury (SCI). The inability to achieve proper storage of urine results in profound quality of life issues, as evidenced by increased morbidity and decreased social relationships [1, 2]. Although anti-cholinergic medication provides a clinically effective means of managing bladder function for persons with SCI, various side-effects limit long-term efficacy.

Peripheral nerve stimulation has emerged as a safe and effective means for treating chronic bladder symptoms. Electrical stimulation of the pudendal nerve, in particular the dorsal genital branch, has been shown to elicit an inhibitory reflex of the urinary bladder. This has been demonstrated in both animals [3] and in persons with chronic SCI [4]. Despite the therapeutic potential, the need for a permanently implanted device is identified as a major limitation for clinically translating this technology.

Posterior tibial nerve stimulation (PTNS) is an alternative peripheral nerve stimulation therapy that has also been shown to be an effective and potentially non-invasive approach for suppressing bladder symptoms [5]. Unfortunately, there is very limited clinical and experimental data that can guide the clinical use of PTNS in patients with chronic SCI. In this paper, we present results from recent animal studies that begin to uncover the underlying neural mechanisms.

II. METHODS

The study involved adult male cats (3-4 kg) that were anesthetized with infusion of alpha-chloralose (i.v., 15mg/kg). The urinary bladder was catheterized to control bladder volume and to also measure intravesicle pressure. Custom-fabricated peripheral nerve cuff electrodes were implanted on the sciatic nerve and the posterior tibial nerve trunk. The tripolar electrode measured stimulation-evoked neural activity, whereas bipolar electrodes were used to stimulate selectively the posterior tibial nerve and its branches. In short, the experimental protocol involved continuous measurement of isovolumetric bladder pressure in response to 1-minute trains of electrical pulses delivered at various stimulation amplitudes (e.g., multiples of stimulation threshold for evoking a foot twitch) and frequencies ($f = 5$ Hz to 50 Hz).

III. RESULTS AND DISCUSSION

Electrical stimulation of the posterior tibial nerve evoked acute changes in bladder pressure. These inhibitory responses were observed at bladder volumes above that for generating distension-evoked activity (infused volume = 15.3 ± 4.7 ml), and were found to depend on both the stimulation frequency and intensity. Robust bladder inhibition was observed at the stimulation amplitudes equal to or greater than the threshold for evoking muscle twitches in the ipsilateral foot and also at stimulation frequencies between 5 Hz to 20 Hz. Further work is needed to clarify the underlying mechanism of PTNS.

ACKNOWLEDGMENT

P.B.Y. thanks Drs. Warren Grill and Will Rosellini for their support in completing this pilot study.

REFERENCES


*Research was supported by Microtransponder Inc. and the University of Toronto.
P.B. Yoo is a professor in the Institute of Biomaterials and Biomedical Engineering at the University of Toronto, Toronto, ON M5S 3G9, Canada (phone: 416-978-7326; fax: 416-978-4317; e-mail: paul.yoo@utoronto.ca).