Physical Medicine and Rehabilitation Research

Editorial

ISSN: 2398-3353

A 12-channel neuroprosthetic platform for SCI: Applications in the urinary, respiratory and muscle atrophy areas

Walter James S[1,4], Posluszny Joseph[1,2], Wheeler John[2,4], Bresler Larissa[2,4], Dieter Raymond A[1], Diete Robert S[3,5], Donald Thomas[1,2], Sayers Scott[1,6] and Sanjay Singh[1]

[1]Research Services, Edward Hines Jr. Veterans Administration Hospital; Hines, IL 60141, USA

[2]Surgery Services, Edward Hines Jr. Veterans Administration Hospital; Hines, IL 60141, USA

[3]Cardiology Services, Edward Hines Jr. Veterans Administration Hospital; Hines, IL 60141, USA

[4]Department of Urology, Loyola University Stritch School of Medicine; Maywood, IL 60153, USA

[5]Department of Cardiology, Loyola University Stritch School of Medicine; Maywood, IL 60153, USA

[6]Department of Thoracic and Cardiovascular Surgery, Loyola University Stritch School of Medicine; Maywood, IL 60153, USA

The NeuRx® Diaphragm Pacing System with Permaloc® Electrodes applies functional electrical stimulation (FES) for respiration in quadriplegic spinal cord injury (SCI) patients. The electrode is an intramuscular barb type with a polypropylene anchor, and the electrode evolved from the original Peterson Intramuscular Electrode developed for diaphragmatic pacing in quadriplegic SCI patients at Case Western Reserve University and Cleveland Veterans Administration FES Center [1]. The NeuRx® system was commercialized by Synapse Biomedical, Inc. in Oberlin, Ohio and uses four Permaloc® electrodes implanted in the diaphragm and a fifth electrode implanted under the skin as a return electrode for monopolar stimulation. All five electrode leads pass through the skin at separate exit sites that are situated close together, and are connected to a small, battery-powered stimulator. Successful respiratory pacing with this system has been reported in over 100 SCI patients with up to ten years of use [2].

A 12-Channel Neuroprosthetic Platform is being developed in a collaborative effort between Synapse Biomedical Inc and our laboratory, Research Service, Hines Veterans Administration Hospital, [3,4]. For this platform, several types of electrodes are under investigation including surface, mapping, intramuscular, and a multi-lead implantable cable with connectors. Several FES applications are also being investigated including respiration, urinary and muscle disuse atrophy with current work focused on optimization of stimulation. Further development of the neuroprosthetic platform is ongoing with a future goal of a small, home-use device.

Optimization of respiratory stimulation is focused on extradiaphragmatic muscles. Positive inspiratory results were obtained in a canine model with surface electrodes applied to the upper thorax (submitted for publication). Large inspiratory volumes were also obtained using three or four sets of bilateral Permaloc® electrodes implanted in intercostal spaces ventral to the axilla and stimulated at 50 Hz, and 30 to 50 mA [5-7]. Positive expiratory results were also obtained for abdominal muscles using surface and Permaloc® electrodes [5-7]. Further work is needed to study effects of stimulation on muscle fatigue and metabolic responses. In one long term study we identified a problem with securing Permaloc® electrodes in extradiaphragmatic muscles [8]. To address this concern we plan to test opening the polypropylene securing barb and snaking the electrode lead away from the muscle exit site and using multiple sutures. A future goal is to combine extradiaphragmatic muscles with diaphragm stimulation for a more complete respiratory and cough management program. A model of glottal closure for cough has been demonstrated [7].

For urinary applications, we are investigating Permaloc® Intramuscular Electrodes for direct bladder wall stimulation and voiding as well as bilateral pudendal nerve stimulation for neuromodulation and bladder inhibition [3,8-11]. Successful clinical methods of Magasi and Simon [12] for direct bladder wall stimulation and Possover *et al.* [13] for pudendal nerve stimulation and neuromodulation are being followed. Management of high urethral resistance during bladder contractions is proposed to be managed with Botulinum toxin injections in the urethra. These injections have already been shown to be useful for SCI individuals using reflex voiding [14]. Thus, outcomes of injections alone should be conducted before stimulation interventions are considered.

For our skeletal muscle disuse atrophy problem, we are following a protocol observed in an SCI individual using the Nashold sacral spinal cord stimulator for urination [15]. Following each stimulation-induce void the stimulator was left on for 15 min causing strong isometric leg contractions. The leg muscles were observed to have great girth and this individual had not experienced pressure ulcers. We conducted isometric leg stimulation tests in a canine model with Permaloc® electrodes implanted adjacent to the lumbar vertebra with the induction of strong contractions (unpublished). We plan to optimize this stimulation protocol with the long term goal of preventing pressure ulcers.

The development of the 12-Channel Neuroprosthetic Platform in collaborative with Synapse Biomedical Inc is continuing. The company is interested in working with any research laboratory that can help with the high costs of developing and testing this technology.

Correspondence to: James Walter, Department of Urology, Loyola University Stritch School of Medicine; Maywood, IL 60153, USA, E-mail: James.Walter@va.gov

Received: April 18, 2017; **Accepted:** April 26, 2017; **Published:** April 28, 2017

Acknowledgement

These investigations are based upon work supported by the Office of Research and Development, the Rehabilitation Research and Development Service of the Department of Veterans Affairs (A0348).

References

1. Chester HH, Triolo RJ, Elias AL,, Kilgore KL, DiMarco AF, et al. (2014) Functional electrical stimulation and spinal cord injury. *Phys Med Rehabil Clin N Am* 25: 631–661.
2. Onders RP, Elmo MJ, Khansarinia S, Bowman B, Dunkin B, et al. (2009) Complete worldwide operative experience in laparoscopic diaphragm pacing: results and differences in spinal cord injured patients and amyotrophic lateral sclerosis patients. *Surg Endosc* 23: 1433-1440. [Crossref]
3. Walter J, Wheeler JS, Bresler L, Sayers JS. Singh S (2015) Neuroprosthetics for SCI bladder Management: the Argument for Direct Bladder Stimulation. *Int J Phys Med Rehabil*.
4. Walter JS, Posluszny J, Wheeler J, Bresler L, Dieter R, et al. (2016) Update on a 12-Channel, Laboratory, Neuroprosthetic Platform for SCI: Respiration, Urinary, and Muscle Disuse Atrophy Applications. *Internal Medicine Review*.
5. Walter JS, Thomas D, Sayers S, Anthony APT, Crish T, et al. (2015) Respiratory responses to stimulation of abdominal and upper-thorax intercostal muscles using multiple permaloc® electrodes. *J Rehab Research Dev*.
6. Walter JS, Thomas D, Sayers, S, Perez-Tamayo RA, Crish A, et al. (2015) Respiratory responses to stimulation of abdominal and upper-thorax intercostal muscles using multiple Permaloc® electrodes. *J Rehab Res Dev* 52: 85-96.
7. Singh S, Walter JS, Dieter R, Sayers S, Kiratipath I, et al. (2016) Respiratory stimulation for cough using a 12-Channel neuroprosthetic platform with intramuscular mapping and Permaloc® electrodes: acute studies in adult canines. *Internal Medicine*.
8. Walter JS, Wurster RD, Zhu Q, Laghi F (2011) Respiratory Muscle Pacing with Chronically Implanted Intramuscular PermalocTM Electrodes: A Feasibility Study. *J Rehab Res Dev* 48:103-114. [Crossref]
9. Bresler L, Walter JS, Jahoda A, Wheeler JS, Turk T, et al. (2008) Effective methods of pelvic plexus nerve and bladder stimulation in anesthetized animal model. *J Rehabil Res Dev* 45: 627-638. [Crossref]
10. Walter JS, Allen JC, Sayers S, Singh S, Cera L, et al. (2012) Evaluation of bipolar Permaloc® electrodes for direct bladder stimulation. *Bentham science Rehabilitation J* 5: 14-21.
11. Allen JC, Walter JS, Sayers S, Singh S, Wang W, et al. (2012) Comparison of bipolar lead electrodes for high-frequency blocking of the pudendal nerve. *The Internet Journal of Urology*.
12. Magasi P, Simon Z (1986) Electrical stimulation of the bladder and gravidity. *Urol Int* 41: 241-245. [CrossRef]
13. Possover M, Schurch B, Henle KP (2010) New strategies of pelvic nerve stimulation for recovery of pelvic visceral functions and locomotion in paraplegics. *Neurourol Urodyn* 29: 1433-1438. [Crossref]
14. BT injections
15. Nashold