The Artificial Somato-Autonomic Reflex Arch Does Not Improve Lower Urinary Tract Function in Patients with Spinal Cord Lesions

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Abbreviations and Acronyms

AIS = American Spinal Injury Association Impairment Scale

SCI = spinal cord injury

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Purpose: The artificial somato-autonomic reflex arch (Xiao procedure) was proposed as treatment for neurogenic bladder dysfunction. We investigated the effects of the procedure on lower urinary tract function.

Materials and Methods: Seven and 3 patients with a median age of 46 years (range 19 to 64) had AIS A and B spinal cord injury, respectively. In these patients an anastomosis was created between the ventral (motor) part of L5 and the ventral part of the S2 root. Urodynamics were performed and a standard questionnaire was completed at baseline and 18 months postoperatively.

Results: Artificial reflex arch stimulation did not initiate voiding or increase bladder pressure. Maximum bladder capacity did not change significantly from baseline to followup (median 427.5 ml, range 168 to 581 vs 498.5, range 271 to 580, $p = 0.09$). Likewise, bladder compliance did not significantly differ at baseline and followup (median 16.9 ml/cm H_2O, range 15.0 to 65.0 vs 25.1, range 17.5 to 50.0, $p = 0.95$). No difference was found in awareness of bladder emptying, incontinence episodes, bladder emptying method or medication use for neurogenic bladder dysfunction. The only statistically significant change was a decreased incidence of leakage at followup on urodynamics ($p = 0.03$). Postoperatively decreased genital sensation and erectile dysfunction developed in 1 patient and another experienced a minor cerebrovascular accident with no long-term complications.

Conclusions: In contrast to earlier findings, creation of an artificial somato-autonomic reflex arch in patients with spinal cord injury had no clinically relevant effect on lower urinary tract function.

Key Words: urinary bladder, neurogenic; spinal cord injuries; anastomosis, surgical; urodynamics; questionnaires

Neurogenic bladder and bowel dysfunction have severe consequences for quality of life in patients with SCI.[1,2] Conservative treatment of bladder dysfunction in SCI cases usually includes anticholinergics combined with clean intermittent catheterization. If that is not sufficient, intravesical botulinum toxin A injections may be considered and ultimately bladder augmentation combined with procedures designed to enhance bladder outlet resistance.

An alternative approach is stimulating intact nerve roots, as known from the Brindley stimulator[3] or

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sacral nerve stimulation.[4–6] Disadvantages of such procedures include high cost, limited battery life and the risk of malfunction or infection. Other options may be nerve anastomosis techniques, especially the artificial somato-autonomic reflex arch or Xiao procedure (fig. 1).[7,8] After initial animal studies in the United States[9,10] treatment was introduced in the People's Republic of China. The latter results were later studied in a small cohort of American patients with spina bifida.[11] It is still recommended that in the future the procedure should be performed in clinical trials.[11,12]

We evaluated the effects of the Xiao procedure on lower urinary tract function. Our hypothesis was that stimulating the dermatome innervated by the Xiao procedure would increase bladder pressure and initiate voiding. We also hypothesized that frequent stimulation of the reflex would decrease neurogenic bladder dysfunction symptoms in patients with SCI.

METHODS

In spring 2009 members of our multidisciplinary team traveled to the Department of Urology, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, People's Republic of China, to observe the surgical technique of the Xiao procedure. On location a number of operative procedures were observed and studied in the operating room. Subsequently and after thorough review of the available literature we planned the current study.

Patients eligible for study inclusion were identified by file review at our neurosurgical department (fig. 2). The local ethics committee approved the project, which is registered on ClinicalTrials.gov (NCT01241630 and NCT01274312). All patients provided informed written consent.

Inclusion criteria were age 18 years or greater, AIS A (complete SCI injury) or B (complete motor injury),[13] injury between spinal cord C4 and L4, a preserved medial hamstring reflex arch and a suitable preoperative electrophysiological response from the relevant nerves ipsilateral to the intended surgery. Exclusion criteria were respirator dependence, malignant urological disease, pharmaceutical treatment affecting lower urinary tract function that could not be withdrawn for at least 24 hours before urodynamics, ileostomy, colostomy and pregnancy or planned pregnancy.

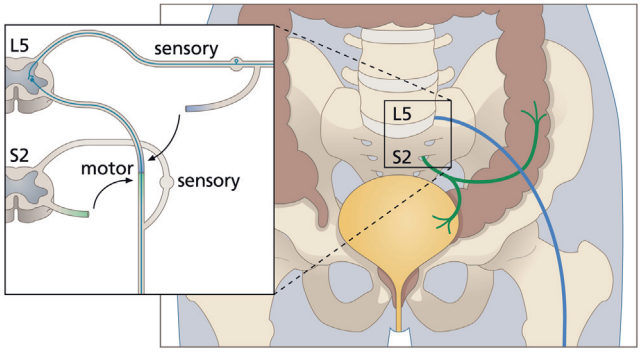

Figure 1. Creation of artificial somato-autonomic reflex arch. Intradural anastomosis was made between ventral (motor) part of L5 and S2 ventral nerve root sheath.

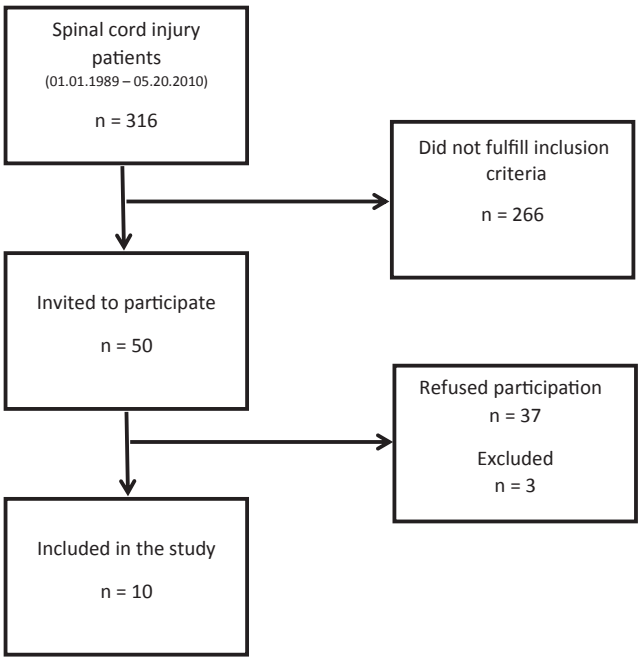

Figure 2. Patients screened for study inclusion

Surgical Procedure

The surgical procedure was performed in accordance with the operating room experiences attained in the People's Republic of China and as described in the previous study by Xiao et al.[7] Surgery was done by an experienced neurosurgeon who had had firsthand experience during the Chinese visit.

Preoperatively electrophysiological evaluation was done to determine the surgical anastomotic level and laterality. Patients underwent L4 and L5 hemilaminectomy, and decompression of the sacral bone to identify the S1 and S2 foramina. The dura was opened under microscope magnification. The L5, S1 and S2 sacral roots were identified ipsilaterally using anatomical localization and intraoperative electrophysiology. S2 was chosen for the anastomosis because a satisfactory electrophysiological response was obtained in all cases. The ventral (motor) root filaments were separated from the dorsal (sensory) filaments and tested by electrophysiology. The dorsal filaments remained intact while the ventral roots or part of 1 root was transected. Microanastomosis was created between the L5 (S1 in 1 case) and S2 by suturing the proximal lumbar ventral L5 and distal ventral S2 nerve root sheath aligned with the dura (fig. 1).

Due to dural opening the patient underwent flat bed rest for 3 days postoperatively. Subsequent mobilization was started slowly. When mobilized, the patients were discharged home. Before surgery and investigations baclofen was withheld for 24 hours.