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The Assessment of Bladder and Urethral Function in Spinal Cord Injury Patients

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Summary：The correlation between the anatomic site of spinal cord injury and real-time conditions of bladder and urethral function was assessed in order to provide a reasonable basis for the clinical treatment of neurogenic bladder. A total of 134 patients with spinal cord injuries (105 males, 29 females; averaged 34.1 years old) were involved in this retrospective analysis, including urodynamic evaluation, clinical examination and imaging for anatomical position, and Bors-Comarr classification. The associations between the levels of injury and urodynamic findings were analyzed. The results showed that mean follow-up duration was 16.7 months (range 8–27 months). Complete spinal cord injuries occurred in 21 cases, and incomplete spinal cord injuries in 113 cases. Of the 43 patients with upper motor neuron (UMN) injuries, hyperreflexia and (or) detrusor sphincter dyssynergia were demonstrated in 30 (69.8%), 31 (72.1%) suffered low bladder compliance (less than 12.5 mL/cmH_2O), 28 (65.1%) had high detrusor leak point pressures (greater than 40 cmH_2O), and 34 (79.1%) had residual urine. Of the 91 patients with lower motor neuron (LMN) injuries, areflexia occurred in 78 (85.7%), high compliance in 75 (82.4%), low leak point pressures in 80 (87.9%), and residual urine in 87 (95.6%), respectively. The associations between the anatomical site of spinal cord injury and urodynamic findings were ill defined. In patients with spinal cord injury, this study revealed a significant association between the level of injury and the type of voiding dysfunction. The anatomical site of spinal cord injury can not be predicted in real-time condition of bladder and urethral function. Management of neurogenic bladder in patients with spinal cord injury must be based on urodynamic findings rather than inferences from the neurologic evaluation.
Key words：spinal cord injury; neurogenic bladder; urodynamics

Spinal cord injury (SCI) often leads to severe neurological dysfunction and disability, which not only affects the individual physiology and psychology, but also gives a heavy burden to families and society. SCI can lead to neurogenic bladder that can cause renal failure, which is the first cause of death in the advanced stage patients [1, 2]. Therefore, how to protect the patients from the occurrence of urinary complications of SCI is very important[3-5].

It is usually correlative between the injured segments of spinal cord and the function of bladder and urethra. However, in clinical practice, SCI at the same part would lead to different performance of vesicourethral function in patients. Clinical data of patients with SCI in our hospital in the last 5 years were summarized and reported in this paper.

1 MATERIALS AND METHODS

1.1 Clinical Data

From June 2003 to June 2008, a retrospective review of the patients recorded that, 134 patients with traumatic SCI were treated, of which 105 cases were males, and 29 were females with the age ranging from 18 to 72 years old (mean 34.1±11.8). All patients had a clear history of traumatic SCI due to traffic accidents, occupational injuries or fall injuries, which were confirmed by the clinical and imaging examination. Forty-nine cases of SCI had been treated with decompression or operative fixation. All the patients had no voiding dysfunction before injury; after injury, however, various degrees of voiding dysfunction occurred, and the patients were treated with different levels of rehabilitation therapy. The time from injury to evaluation was 8 to 27 months (mean 16.7±6.3 months).

1.2 Methods

All patients were diagnosed by careful physical examination to locate the injured position, including the determination of dysfunction levels of sensation and locomotion, such as the state of sensation, motion, myodynamia, tendon reflex, muscular tension and pathologic reflex of both lower extremities, the sensation of perineum, autonomic contraction of anus, anus reflex and so on. The results were classified according to Bors-Comarr classification method[6].

Urodynamic studies were performed on all patients

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by Triton® urodynamic detector from Laborie Medical Technologies Inc. of Canada. Parameters measured included residual volume, bladder press-volume measurement, press-flow examination and electromyogram to realize bladder volume, compliance, stability and the coordination of detrusor with external sphincter. Video urodynamic examination was carried out on 29 patients. The relationship between the urodynamic results and the injured spinal cord segments were analyzed.

χ^2 test was used for statistical data analysis. For all statistical tests, $P<0.05$ was considered significant.

2 RESULTS

According to Bors-Comarr classification method, among the 134 patients, 43 suffered upper motor neuron (UMN) injury, including 23 with cervical vertebra injury and 20 with dorsal vertebra injury; 91 patients suffered lower motor neuron (LMN) injury; 21 patients suffered complete nerve injury and 113 suffered incomplete injury. Of the 43 patients with UMN injuries, 30 (69.8%) were demonstrated with hyperreflexia and (or) detrusor sphincter dyssynergia, 31 (72.1%) had low bladder compliance, 28 (65.1%) had high detrusor leak point pressures (DLPP), and 34(79.1%) had residual urine (RU). Of the 91 patients with LMN injuries, 78 (85.7%) were manifested with areflexia, 75 (82.4%) had high compliance, 80 (87.9%) had low leak point pressures, and 87 (95.6%) had residual urine. However, there were 12 cases (27.9%) who exhibited high compliance in the patients with UMN injury, and 16 cases (17.6%) who exhibited low compliance in the patients with LMN injury. The urodynamic results of a patient with T8 complete SCI one year after the injury were shown in fig. 1. The patients exhibited a large bladder capacity and high compliance bladder.

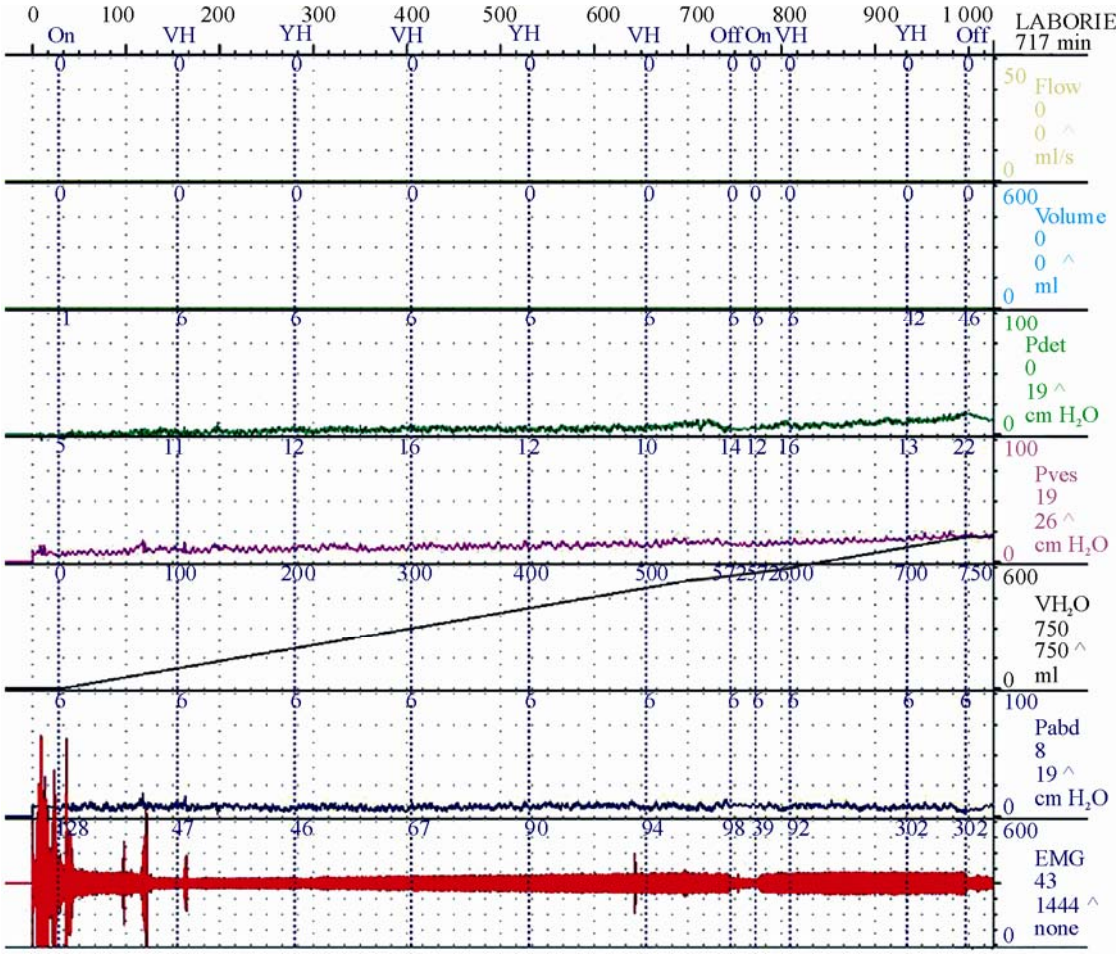

Fig. 1 The urodynamic results of a patient, one year after complete T8 injury
Flow: Flow rate; Volume: Voided volume; Pdet: De- trusor pressure; Pves: Vesical pressure; Pabd: abdominal pressure; VH_2O: Filling volume; EMG: electromyogram

Information of each group of patients with urodynamic finding, such as bladder compliance (BC), DLPP, detrusor hyperreflexia (DHR) and RU, was listed in the table 1. It was shown BC values lower than 12.5 mL/ H_2O meant low compliance, and the critical value of DLPP was 40 mH_2O. If non-autonomous detrusor contraction appeared in bladder filling phase, it was positive for DHR, and RU in the bladder was positive if it was more than 100 mL.

Table 1 Comparison of the urodynamic results of patients with SCI

Groups	*n*	BC		DLPP		DHR		RU	
		Low	High	≥40 H_2O	<40 H_2O	Positive	Negative	Positive	Negative
UMN	43	31	12	28	15	30	13	34	9
LMN*	91	16	75	11	80	13	78	87	4
Total	134	47	87	39	95	43	91	121	13

*There was significant difference in BC, DLPP, DHR and RU between UMN and LMN groups (P<0.01)

3 DISCUSSION

The annual incidence rate of SCI was (20–40) per million. Its treatment is still one of the most difficult problems in the world. The society is assailed with problems of the loss of working capacity, disability and severe complications of the SCI patients. Neurogenic bladder and a series of complications might accompany the patients all their lives, which were the main reasons leading them to death[7]. Accurate evaluation and reasonable treatment of neurogenic bladder are the keys to reduce complications and to allow patients to enjoy almost normal and high-quality lives[8, 9].

In 1994, International Medical Society of Paraplegia (IMSOP) recommended to adopt the standard for neurological classification of SCI prepared by American Spinal Injury Association (ASIA) as the international standard in application, which was modified in 2000[10]. The basic concept of the standard was definite, of which the indices were objective and repeatable. This standard has been widely adopted in the world. It emphasizes the location and estimation of limb sensation and motor function, however, other than the effect of spinal cord on function of bladder or the function of urethra of different injured segments. The standard can't be used as a guide for the treatment of neurogenic bladder.

Almost all SCI would induce various degrees of abnormalities in lower urinary tract function. Voiding dysfunction or urinary incontinence occurred to these patients in clinical practice. At present, there is not yet a perfect classification of neurogenic bladder resulted from SCI[11]. Bors-Comarr classification system is used mainly in voiding dysfunction at the end of spinal shock phase of SCI. Based on the anatomy of lesions, nerve injuries are divided into UMN and LMN; the former means the above sacral SCI, while the latter is sacral dorsal or sacral nerve root injury. Moreover, according to the classification system, the diseases are divided into complete and incomplete injuries in accordance with the severity of nerve injury; according to RU, they are also divided into "balanced" or "non-balanced" lower urinary tract function. This classification system, to a certain extent, reflects the function of bladder and urethra. As cases in this study, UMN injury was mainly expressed in patients as low compliance, high DLPP and DHR-based, and LMN showed high compliance, low DLPP and decreased performance of detrusor contractility. However, the classification system can not accurately reflect the real-time status of vesicourethral function of each SCI patient, e.g., high compliance bladder and low compliance bladder occurred respectively in UMN and LMN groups, which might lead to confusion during the preparation of appropriate plan of treatment.

The position of human primary spinal cord micturition center is relatively fixed. Neurogenic bladders caused by spinal injury have a certain degree of common characters or rules, but in fact these rules are not strictly followed. Some literatures reported that there was no strict correlation between the injury position of the marrow and the urodynamic results; even the existing theory can not be used to explain why a certain SCI would lead to certain clinical symptoms and urodynamic results[12-15]. Of the 43 patients with UMN injuries in our study, 12 cases (27.9%) had high compliance bladder, 15 cases (34.9%) had a DLPP less than 40 cmH_2O, and 13 cases (30.2%) exhibited no DHR; in contrast, among the LMN injury patients, there were also 16 cases (17.6%) with low compliance bladder, 11 cases (12.1%) with a DLPP more than 40 cmH_2O, and 18 cases (19.8%) had DHR.

Chua *et al* [16] reported a urodynamic study on 47 patients with new traumatic SCI, which was conducted one year after the injury. In 10 patients with complete cervical injuries, 80% (n=8) had detrusor sphincter dyssynergia (DSD), and areflexia was seen in 20% (n=2). Of those 16 patients with incomplete cervical injury, 7 (43.8%) had DSD, 5 (31.3%) had DHR without DSD, and 2 (12.5%) had areflexia or hyporeflexia; only 2 patients had normal urodynamic performance (n=2). Of the 6 patients with thoracic injury, 4 (66.6%) had detrusor areflexia and 2 had DSD. The 2 patients with DSD had injury levels at T4/T6 and T5 respectively. Among the 14 cases of lumbar injury, 11 (78.6%) had detrusor areflexia, one (7.1%) had DHR (without DSD), and 2 (14.3%) had a normal urodynamic performance.

Weld *et al* [17] reported the relationship between SCI site and video urodynamic results of 243 patients with complete spinal CT or MRI imaging. All patients aged 18 to 78 years (mean 39.1±11.9 years), and the average follow-up duration after SCI was 18.6±12.0 years. A total of 196 patients suffered sacral cord upward injuries (i.e. the number of cervical, thoracic and lumbar spine injuries were 114 cases, 54 cases and 28 cases, respectively), 186 patients (94.9%) exhibited urodynamic DHR and (or) DSD, 82 patients (41.8%) suffered reduced bladder compliance (less than 12.5 mL/cmH_2O), 79 patients (40.3%) had increased DLPP (higher than 40 cmH_2O); simple sacral vertebral injury occurred in 14 cases, 12 cases

(85.7%) showed detrusor areflexia, 11 cases (78.6%) had reduced bladder compliance, and 12 cases (85.7%) had increased DLPP. There were 33 cases of sacral vertebrae with other spinal injury patients, including 12 cases of cervical, 7 cases of thoracic and 14 cases of lumbar spine. Among the 33 patients, 23 cases (67.7%) exhibited DHR and (or) DSD, 9 cases (27.3%) showed detrusor areflexia, 19 cases (57.6%) had reduced bladder compliance, and 20 cases (60.6%) increased DLPP. The author believed that this non-correspondence relationship was due to: (1) degeneration and regeneration of injured important parts of remote neural pathways, with (without) the formation of new nerve tissue, which would directly affect the symptoms of nervous system and urodynamic performance; (2) incomplete SCI, therefore the nervous system had some residual functions of signal integration and regulation for voiding at different levels; (3) multiple injuries at different levels, which could also make it difficult to predict the complexity of the performance of voiding dysfunction.

Pathological changes after SCI are complex and changeable. SCI may occur not only at the site of bone fracture, but also at the parts higher or lower due to the conduction of external force during injury. Vertebral fractures also can damage the spinal cord artery, in particular, the main artery of the injured spinal cord root, so that sections following SCI and extensive damage due to ischemia. Therefore, even if there are the same sections in various spinal injuries, spinal cord injured at the sections may have some differences, and the function of spinal cord below the section injured also differs significantly; the effect on lower urinary tract is also quite complex in clinic.

In fact, for patients with incomplete spinal cord transection injury, because of the difference in conductive function of residual control center for voiding in spinal cord and spinal nerve tract, there is also a great difference in bowel or voiding abnormalities, performance of motor function and other physical feeling. Even for some patients with completely cross-sectional injury, after an early appropriate treatment, a part of spinal cord function could be recovered. Patients often exhibited some symptoms of the corresponding SCI syndrome, and the degree of injury sometimes wasn't as serious as the complete injury. Therefore, for patients with incomplete SCI, the clinical evaluation was totally dependent on the examination of abnormal urinary symptoms and the nervous system, especially urodynamic studies[18-20].

It can be concluded that the type of voiding dysfunction could not be assumed simply based on the site of spine injury; accurate evaluation of voiding function of patients is dependent on the timely and dynamic examination of urodynamics. In Weld *et al*'s reports[17], the proportion of patients with low compliance and high DLPP was relatively high, which may be due to the long follow-up duration and the loss of bladder function at the advanced stage.

The clinical observation in this study revealed that the type and status of neurogenic bladder can not be predicted according to the site of SCI. Urodynamic examination aims at the functional changes of bladder and urethra. The anatomy abnormality could be found if synchronous video examination was performed, such as vesicoureteral reflux, bladder diverticulum, sphincter dysfunction and so on. Urodynamic studies are used routinely to evaluate bladder function after SCI. They are the "gold standard" for evaluating bladder and sphincter function and for documenting the effectiveness of new drugs or other treatment modalities.

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