CASE REPORT

Traumatic pediatric spinal cord injury: long-term outcomes of lower urinary tract function

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Long-term urodynamic and urological outcomes were evaluated in pediatric patients following traumatic spinal cord injury (SCI). The medical charts of three pediatric patients following traumatic SCI were retrospectively reviewed. The level of the injury was cervical in two patients and thoracic in one. Two patients, whose initial urodynamics demonstrated voluntary or reflex detrusor contraction with synergic sphincter relaxation, managed to void; however, urinary management was switched in one of these patients from voiding to clean intermittent catheterization (CIC) with anti-cholinergic agents because of a treatment for urinary incontinence. There were also no episodes of hydronephrosis, vesicoureteral reflux (VUR) or renal dysfunction in these two patients. Although one patient with hyperreflexic bladder was initially managed with CIC and anti-cholinergic agents, detrusor myectomy was ultimately performed because of severe VUR associated with the progressive worsening of lower urinary tract (LUT) function. Careful follow-ups including urodynamics are mandatory for children with progressively deteriorated LUT function or problematic urinary incontinence.

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INTRODUCTION

Information on the long-term prognoses of pediatric patients following traumatic spinal cord injury (SCI) is limited in spite of differences in the characteristics of pediatric and adult SCI. Historically, early pediatric studies revealed that pediatric SCI patients were commonly managed with reflex voiding and the use of anti-cholinergic agents was infrequent, which resulted in upper urinary tract changes in a significant proportion of patients.^{1,2} However, following the introduction of urodynamics, clean intermittent catheterization (CIC) and administration of anti-cholinergic agents to pediatric SCI patients, the management of lower urinary tract (LUT) with CIC and anti-cholinergic agents, which is dependent on urodynamic outcomes, has prevented hydronephrosis, renal scarring, vesicoureteral reflux (VUR) and bladder trabeculation.^{3–5} In the present study, we retrospectively summarized the long-term urodynamic and urological outcomes of pediatric-onset SCI.

CASE REPORT

Patient (1)

A girl with a C2 incomplete injury due to a traffic accident at the age of 3 was followed up at our hospital. CIC with anti-cholinergic agents was initially introduced for urinary management. However, video-urodynamics (V-UDS) was performed at the age of 5, which revealed that LUT function possessed voluntary or reflex detrusor contraction with synergic sphincter relaxation in addition to detrusor overactivity (DO). Urinary management was switched to self-voiding with anti-cholinergic agents. Uroflowmetry and post-void residual urine volume at 13 years of age (10 years after SCI) are shown in Figure 1. Ultrasonography revealed the absence of abnormalities in the upper urinary tract at 15 years of age (12 years after SCI) and voluntary self-voiding has been possible

with ambulatory ability; however, minor urinary incontinence still persists.

Patient (2)

A boy with a C7 incomplete injury due to a traffic accident at the age of 2 had initially been managed with self-voiding because urodynamics revealed voluntary or reflex detrusor contraction with synergic sphincter relaxation in addition to DO. At the age of 5, he and his family expressed the desire to treat his urinary incontinence and stop using diapers. Although anti-cholinergic agents were prescribed, urinary incontinence persisted and the residual urine volume increased. Therefore, urinary management was switched from self-voiding to CIC with anti-cholinergic agents. His activity of daily living is now in a wheelchair, and urinary incontinence is currently managed without the complication of urinary tract infections (UTI) or renal scarring at 8 years of age (6 years after SCI).

Patient (3)

A boy with a T6 complete injury due to a traffic accident at the age of 5 had initially been followed with CIC and anti-cholinergic agents because of DO and detrusor-urethral sphincter dyssynergia (DSD). Since his urodynamic parameters gradually deteriorated and febrile UTI occurred with bilateral VUR during the follow-up, other conservative therapies such as the intravesical instillation of anti-cholinergic agents and capsaicin were performed. However, these conservative therapies were not effective and urodynamics revealed the deterioration of urodynamic parameters (Figure 2). Detrusor myectomy was ultimately performed when he was 12 years of age. V-UDS at 15 years of age (9 years after SCI) showed good bladder compliance with a large bladder capacity (BC) and no evidence of DO or VUR (Figure 3). His activity of daily living is

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Figure 1. Clinical course in patient (1). LUT function in this patient exhibited voluntary or reflex detrusor contraction with synergic sphincter relaxation in addition to DO. Urinary management was switched to self-voiding with anti-cholinergic agents. Voluntary self-voiding was possible with a good flow and less post-void residual urine. DO, detrusor overactivity; DSD, detrusor-sphincter dyssynergia; PVR, post-void residual urine volume; Qave, average flow rate; Qmax, maximum flow rate; PVR, post-void residual urine volume; UFM, uroflowmetry; V-UDS, video-urodynamics; VV, voided volume.

Figure 2. Clinical course in patient (3). Urodynamics in this patient revealed the deterioration of LUT function in spite of several conservative therapies during the follow-up period. BC, bladder capacity; DO, detrusor overactivity; DSD, detrusor-sphincter dyssynergia.

now in a wheelchair, and urinary management is currently performed without evidence of urinary incontinence, febrile UTI or the new formation of renal scarring at 21 years of age (16 years after SCI).

DISCUSSION

The major goal of treatments for LUT dysfunctions in SCI patients is the protection of renal function by maintaining a lower intravesical pressure during filling and emptying of the urinary bladder. Historically, early studies recommended that SCI patients with no VUR and residual urine volume of less than one-third BC be considered as having balanced bladders and managed without catheters. Other SCI patients who did not have balanced bladders required indwelling catheters.^{1,2} However, urodynamics revealed high voiding pressures by DSD and DO in SCI patients who were previously considered to have balanced bladders. A previous study by Fanciullacci *et al.*⁶ showed that only 8 out of 14 pediatric patients (57%) with balanced bladders exhibited no deteriorations in the upper urinary tract during follow-ups. Therefore, urodynamics are regarded as important tools for evaluating LUT

Patient (3): V-UDS 9 years after SCI

Figure 3. Video-urodynamics after detrusor myectomy 9 years after SCI in patient (3). V-UDS after detrusor myectomy showed good bladder compliance with a large bladder capacity and no evidence of DO or VUR. BC, bladder capacity; Cves, bladder compliance; DO, detrusor overactivity; Pabd, abdominal pressure; Pdet, detrusor pressure; Pves, vesical pressure; V-UDS, video-urodynamics; VUR, vesicoureteral reflux.

function in and selecting appropriate urinary management for SCI patients, and close follow-ups are also necessary for assessing LUT function and examining the upper urinary tract. Chao *et al.*⁵ recommended yearly ultrasonography and V-UDS every 1–2 years for pediatric SCI patients. Other studies also reported that close follow-ups were necessary and appropriate urinary management, which is dependent on the neurological level and type of injury, needed to be conducted for pediatric SCI patients because urodynamic characteristics, including other neurological characteristics, may change with natural growth.^{3,4} Thus, urinary management needs to be reconsidered based on the findings of urodynamic evaluations during long-term follow-ups in pediatric SCI patients.

Since the introduction of CIC by Lapides *et al.*,⁷ CIC and anti-cholinergic agents have gradually been accepted as LUT management for SCI patients with a high detrusor pressure in the voiding and filling phases.⁷ CIC is now the mainstay for the management of neuropathic LUT dysfunction, both to improve continence and to preserve the urinary tract and kidneys. SCI patients with adequate hand function are able to empty their bladder regularly using self-CIC as the safest and most appropriate method of LUT management for SCI;⁸ however, alternative managements such as suprapubic catheters need to be considered for adult quadriplegic patients without adequate hand function.⁹

Even in pediatric SCI patients whose urodynamics in the voiding and filling phases showed a high detrusor pressure caused by DSD and DO or no micturition reflex, urinary management is basically early CIC with or without the use of anti-cholinergic agents, which prevents upper urinary tract deterioration, improves continence and decreases UTI. However, before the introduction of CIC for pediatric patients, it is important to note that not all pediatric patients are initially capable of performing CIC by themselves; therefore, parents or caretakers need to performed CIC for these patients. Patients as well as parents or caretakers need to be educated on the importance of CIC because persistent urinary incontinence and frequent UTI after the introduction of CIC may basically be derived from non-compliance with catheterization schedules. Otherwise, alternative urinary management strategies to CIC need to be considered to prevent complications.

Two patients were initially managed with self-voiding after voluntary or reflex detrusor contraction with synergic sphincter

relaxation had been confirmed by V-UDS. The development of high pressure in the bladder, such as the strength of detrusor contractions and duration of high detrusor contractions, is known to be crucial for the long-term outcomes of LUT as well as the kidneys and upper urinary tract. Reflex voiding may actually be based on a non-physiological sacral reflex in SCI patients and, thus, is a potentially dangerous procedure with a limited role in these patients. Since we are currently unable to establish whether voiding is triggered by voluntary or reflex detrusor contraction in pediatric SCI patients, those managed with self-voiding have the potential of developing deteriorated LUT function, hydronephrosis and renal impairment.¹⁰ Furthermore, since abnormalities such as scoliosis, kyphosis, lordosis and syringomyelia may occur in SCI children with long-term follow-ups, which may induce neurological deterioration,¹¹ LUT function may be altered during follow-ups with an impact on the kidneys and upper urinary tract.^{4,12} Therefore, urodynamics need to be performed in all SCI patients who start or continue self-voiding during follow-ups. Continence is a major issue for many patients on reflex voiding due to spontaneous contractions of the detrusor muscle. To control urinary incontinence with natural growth, other treatment modalities, such as anti-cholinergic agents and CIC, may be considered for these patients. Urinary management in one patient, who was initially managed with self-voiding and needed to wear diapers all day, was switched from self-voiding to CIC with anti-cholinergic agents during the follow-up period in the present study to manage urinary incontinence.

Although one patient with a thoracic injury who had hyperreflexic bladder was initially managed with CIC and anti-cholinergic agents, upper urinary tract deterioration such as severe VUR and UTI occurred during the follow-up, and detrusor myectomy was ultimately performed. LUT functional patterns in thoracic injury patients were previously reported to vary the most and exhibit more changes than those in cervical or lumbar injury patients.⁴ We observed a decrease in BC with pronounced DO, VUR, and recurrent UTI during the follow-up despite the introduction of CIC and anti-cholinergic agents or other conservative treatments in this patient. These results demonstrated the importance of close regular follow-ups with upper urinary tract imaging using ultrasonography and urodynamics for the selection of appropriate treatments including surgery.

We perform urinalysis and ultrasonography on the upper urinary tract and bladder on a regular basis in follow-ups at our hospital because neurological deterioration with natural growth may occur in pediatric SCI patients during long-term follow-ups¹¹ and affect urodynamic parameters in LUT function.⁴ If we observe persistent pyuria or bacteriuria in urinalysis, deterioration of the upper urinary tract and clinical manifestations of urinary incontinence or febrile UTI during follow-ups, then urodynamics need to be performed again to evaluate LUT function. Furthermore, the preservation of renal function is one of the important factors for SCI patients, particularly pediatric patients, because of natural growth. Regular examinations (for example, once a year) are

necessary to check renal function and/or renal scarring during follow-ups.

Social circumstances need to be considered when selecting urinary management for pediatric SCI patients with natural growth because urinary incontinence may influence the development of self-esteem and disturb the establishment of social associations with others when these patients start school. We also need to consider the side effects of antimuscarinic drugs, awareness and sexuality, which may influence therapeutic approaches, during long-term follow-ups. Although urodynamics are initially performed to evaluate LUT function, we need to select appropriate urinary management based on the social circumstances of each patient in addition to the results of urodynamic evaluations.

In conclusion, urodynamics are an important tool for evaluating LUT function, and urinary management was affected by LUT function as well as the natural growth and mental health of growing children in the present study. Therefore, urodynamics need to be performed again to evaluate appropriate urinary management if deterioration of the upper urinary tract and bladder or clinical manifestations of urinary incontinence and febrile UTI occur during regular follow-ups.

COMPETING INTERESTS

The authors declare no conflict of interest.

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