Original Article

Long-term Follow-up of Spinal Cord Injured Patients with Vesicoureteral Reflux

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ABSTRACT

Objectives: to investigate the management of VUR, outcomes after treatment and factors associated with VUR outcomes in SCI patients.

Study design: Retrospective data collection

Setting: Maharat Nakhon Ratchasima Hospital

Subjects: Spinal cord injured patients admitted to the Rehabilitation ward between August 2008 and July 2019.

Methods: The medical records of 59 spinal cord injured (SCI) patients with 81 vesicoureteral reflexes (VUR) admitted to our hospital between August 2008 and July 2019 with minimum one-year follow-up were reviewed retrospectively. General demographics, urological information, including bladder management, medications, urodynamic studies, eGFR, UTI, calculi and imaging, including hydronephrosis, bladder deformity and VUR grading, were investigated. Grading of VUR during follow-up were compared to the initial assessment and classified into good (transient or improved) vs poor (stable or progress) outcomes. Bivariate analysis was performed to examine an association between urological variables and good or poor outcomes.

Results: The majority of VUR (83%) developed within 4 years after SCI. Before VUR was detected, only 23.7% of the patients received antimuscarinic medication and the most common bladder management was indwelling catheterization (69.5%). Management post-VUR included indwelling catheterization (83.1%), antimuscarinics (98.3%) and antibiotics (72.7%). VUR outcomes were noted to be transient in 23.7%, improved in 30.5%, stable in 18.6%, and progressive in 27.1%. One patient had eGFR that revealed CKD stage 5 which needed hemodialysis. Three patients had impaired renal function assessed by renal scan. Follow-up VUR was categorized into 2 groups (good vs poor outcomes). Patients with low bladder compliance showed a significant association with poor outcome. High detrusor pressure (Pdet > 40 cmH_2O) tended to have poor outcome but did not reach statistical significance. Indwelling catheterization and antibiotic prophylaxis for management of VUR did not show a significant difference in outcomes.

Conclusion: VUR remains an important complication in SCI-patients, leading to upper urinary tract deterioration. About half of VUR patients improved after conservative treatment. Bladder compliance was a factor associated with VUR outcome. Indwelling catheterization or antibiotic prophylaxis did not prevent progression of VUR. Early urological management and regular urological evaluation should be performed in SCI patients.

Keywords: spinal cord injuries, vesico-ureteral reflux, hydronephrosis, urodynamics, long-term outcome

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Introduction

Vesicoureteral refluxes (VUR) is one of the complications in spinal cord injured (SCI) patients with neurogenic lower urinary tract dysfunction (NLUTD) leading to upper urinary tract (UUT) deterioration. The etiology of VUR in NLUTD is not well estabished, however several studies have purposed the etiology of VUR as a combination of recurrent urinary tract infection (UTI), sustained high detrusor pressure, sacculation associated with the ureteric orifice[1] and neurogenic dysfunction of vesico-ureteric junction and trigone.[2] The management of VUR is usually complex and individualized.[3] Several studies reported the use of antibiotic prophylaxis[4,5] and indwelling catheterization for management of VUR.[6,7] However, some studies have shown antibiotic prophylaxis[8,9] and catheter[6,7] does not protect the kidney from damage. In Thailand, the prevalence of VUR was 11-24%.[10-12] with conflicting management. In our sevice, many patients with VUR were treated with indwelling catheterization and antibiotic prophylaxis but many of them still had VUR progression, pyuria and UTI. The objective of this study was to investigate the management of VUR, outcomes after treatment and factors associated with VUR outcomes in SCI patients.

Methods

We retrospectively reviewed the electronic medical records and imaging results of all SCI with VUR admitted to the Rehabilitation Ward, Maharat Nakhon Ratchasima

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Hospital between August 2008 and July 2019. The yearly urological check-up protocol in our hospital consists of imaging including ultrasonography, intravenous pyelogram (IVP), cystography or voiding cystourethrography (VCUG), laboratory tests including serum creatinine, urinalysis and urodynamics or cystometry. The protocol can be adapted as necessary due to each individual's condition. Data from the initial detection of VUR to the last follow-up were studied. Because the urological check-up protocol in our hospital is yearly, patients with follow-up time of less than one year were excluded. The data from each check-up were divided into 3 parts which were general demographics, urological, and imaging data.

The general demographics including gender, age at onset, level of injury, completeness and cause of spinal cord injury, time interval from SCI to VUR, age at VUR and ambulatory level were recorded. The previous study stated that injury at T10-L2, where the sympathetic intermediolateral nuclei that mediate sphincter relaxation during voiding are located, is associated with the highest incidence of VUR.[13] The authors categorized level of injury into 3 groups: cervical to thoracic 9, thoracic 10 to lumbar 2 and lumbar 3 to sacral. The ambulatory level was classified into ambulatory (score of 3 or greater) and non ambulatory (score less than 3) according to the Mobility for Moderate Distances subscale of the Spinal Cord Independence Measure version III (SCIM III).[14]

The urological data, including type of bladder management: indwelling catheterization, clean intermittent catheterization (CIC), voluntary voiding with continence, triggered reflex voiding with incontinence and voiding plus CIC; antimuscarinic medication used; a history of UTI and upper tract calculi (renal and ureteric calculi), were investigated. Urodynamics or cystometry were performed in some patients. The parameters including bladder compliance, maximum cystometric capacity and detrusor pressure were recorded. Bladder compliance was defined by dividing the change in volume by the change in detrusor pressure, where < 20 mL/cmH_2O considers low bladder compliance.[15] Bladder capacity less than 200 mL was identified as small bladder capacity.[16] Detrusor pressure more than 40 cmH_2O at filling phase was defined as high detrusor pressure (Pdet > 40).[17] Renal functions were evaluated using estimated glomerular filtration rate (eGFR) calculated from CKD-EPI equation and classified into chronic kidney disease (CKD) staging 1-5.[18] Impaired renal function was also identified by renal scan or small kidney from ultrasound.

The imaging data including hydronephrosis, bladder deformity, VUR side (unilateral or bilateral) and grading of VUR were assessed by radiologists. International reflux committee study criteria to grade the reflux were used.[19] Hydronephrosis was detected from ultrasonography or IVP whereas VUR was detected from voiding cystourethrography (VCUG) or cystography. Bladder deformity was classified into 4 grades (grade 0 to 3) according to Ogawa T's classification.[20] For statistical analysis, bladder deformity was grouped into low (grade 0-1) and high grade (grade 2-3) deformity.

The urological data and imagings were examined at every check-up. Grading of VUR at final follow-up was compared to the initial VUR and classified into 4 levels; transient if VUR disappeared by the next evaluation; improved if VUR improved in grading or from bilateral to unilateral; stable if no change in grade of VUR; and progressive if grading of VUR worsened or changed from unilateral to bilateral. Hydronephrosis and bladder deformity were compared and classified into 3 levels; improved, stable, and progressive. VUR at follow-up was defined into good and poor outcomes for statistical analysis. A good outcome was achieved when follow-up VUR was transient or improved. A poor outcome was identified when follow-up VUR was stable or progressive.

Data were analysed using descriptive statistics for demographic and urological data. Bivariate analysis was performed to examine an association between urological variables and good or poor outcomes, using Student's t-test, Fisher's exact test, Chi-square and Mann-Whitney U test, as appropriate. $p < 0.05$ was considered to indicate significance.

Remark: The present study was approved by the Ethics Committee of Maharat Nakhon Ratchasima Hospital (No. 084/2019)

Results

Sixty-three SCI patients had VUR but 4 patients were excluded due to no follow-up VUR data for comparison. Fifty-nine SCI patients with 81 renal units of VUR were evaluated. The majority of VUR (83%) developed within 4 years after SCI. The median time interval from SCI to VUR was 19 months (range, 2-180). The mean age at the onset of SCI and VUR were 37.8 years (range, 3-75) and 40.4 years (range, 7-77) respectively. Eighty-six percent were males. Thirty-seven percent of the patients had SCI at cervical to T9, 42% T10 to L2 and 20% L3 to sacral level. Sixty-six percent had complete lesion, and 73% of injuries were caused by trauma. There were 22% who could walk for a moderate distance. The clinical characteristics of the studied population are shown in Table 1. Of 59 patients, 39 (75%) had urodynamic/cystometry results. Just about half of this group (51.3%) had Pdet > 40, 74.4% had low bladder compliance and 43.6% had small bladder capacity (< 200 mL). Eighty-five percent had a history of UTI and 3.4 percent had upper tract calculi. Eleven patients (18.6%) had impaired renal function. Three patients were assessed by renal scan and 8 patients were assessed by ultrasound. CKD staging from eGFR are shown in Table 1.

The urological data of the patients at which first VUR was detected are shown in Table 2. The most common bladder management was indwelling catheterization (69.5%) followed by triggered reflex voiding with incontinence (20.3%) and voiding plus CIC (10.2%). Antimuscarinics were prescribed to 23.7% of the patients. The reflux was bilateral in 22

Table 1. Clinical characteristics of the patient population (n=59)

Characteristics	Value
Mean age at onset of SCI (years)[1]	37.8 (17.9)
Mean age at onset of VUR (years)[1]	40.4 (17.7)
Time interval from SCI to VUR (months)[2]	19 (10-37, 2-180)
Gender: male[3]	51 (86.4)
Level of spinal cord injury[3]	
Cervical - T9	22 (37.3)
T10 - L2	25 (42.4)
L3 - Sacral	12 (20.3)
Complete lesion[3]	39 (66.1)
Cause of spinal cord injury: Trauma[3]	43 (72.9)
Ambulatory level: ambulatory[3]	13 (22.0)
Urodynamics data[3]	
Pdet > 40 cmH_2O (n=39)	20 (51.3)
Low bladder compliance (n=39)	29 (74.4)
Cystometric capacity < 200 mL (n=39)	17 (43.6)
UTI[3]	50 (84.8)
Upper tract calculi[3]	2 (3.4)
eGFR[2]	112 (92-131, 7-169)
CKD staging[3]	
Stage 1	45 (76.3)
Stage 2	6 (10.2)
Stage 3	6 (10.2)
Stage 4	1 (1.7)
Stage 5	1 (1.7)
Impaired renal function[3]	11 (18.6)

T, thoracic; L, lumbar; VUR, vesicoureteral reflux; UTI, urinary tract infection; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease
[1]Mean (SD); [2]median (IQR, range); [3]number (%)

Table 2. Urological data of the patient population at first VUR detection

Characteristics	Value
Bladder management before VUR[1]	
Triggered reflex voiding with incontinence	12 (20.3)
Void + CIC	6 (10.2)
Indwelling catheterization	41 (69.5)
Antimuscarinics[1]	14 (23.7)
VUR on initial investigation[1]	33 (55.9)
VUR side[1]	
Unilateral	37 (62.7)
Bilateral	22 (37.3)
Grading of VUR[1] (n=81 units)	
Grade I	19 (23.5)
Grade II	12 (14.8)
Grade III	40 (49.4)
Grade IV	6 (7.4)
Grade V	4 (4.9)
Bladder deformity[1]	
Grade 0-1	37 (62.7)
Grade 2-3	22 (37.3)
Hydronephrosis[1]	15 (25.4)

CIC, clean intermittent catheterization; VUR, vesicoureteral reflux
[1]Number (%)

(37.3%) and unilateral in 37 patients (62.7%). Thirty-three patients (56%) had VUR on initial investigations; 25% had hydronephrosis.

The urological data of post VUR are shown in Table 3. After VUR was detected, there were 16 patients (27.12%) who had their bladder management changed. Indwelling catheterization was the most common form of bladder management and increased when compared to when VUR was first detected (69.5% to 83.1%). Suprapubic catheterization was performed in one patient. Almost all patients (98.3%) received antimuscarinics and 73% received antibiotic prophylaxis as treatment for VUR. The time interval from the first VUR to the last follow-up was 33 months (range 12-108). On follow-up, VUR had improved in 54% (23.7% transient, and 30.5% improved) and had not improved in 46% (18.6% stable, and 27.1% progressive). However, hydronephrosis and bladder deformity improved only 13.6% and 20.7% respectively. A focus on UUT deterioration from CKD stage 3-5 and abnormal renal scan, reveals there were 11 patients who had UUT deterioration. Eight patients (72.7%) used indwelling catheterization in this impaired renal function group. About half of the patients who had impaired renal function had transient or improvement of VUR on follow-up whereas almost all of the patients were stable and progressive on ultrasound and bladder deformity. Two patients died (1 from UTI septic shock and 1 from pulmonary tuberculosis), and 1 patient required hemodialysis. One patient who had CKD stage 5 and was on hemodialysis used an indwelling catheter for bladder management. He had VUR on his first urological evaluation at 10 months after SCI and then VUR had disappeared on the next evaluation. But the ultrasound showed progression from normal renal calyx to hydronephrosis and bladder

Table 3. Urological data of post VUR

Characteristics	Value
Bladder management post VUR[1]	
Voluntary voiding with continence	1 (1.7)
Triggered reflex voiding with incontinence	5 (8.5)
Void + CIC	4 (6.8)
Indwelling catheterization	49 (83.1)
Medication post VUR[1]	
Antimuscarinic	58 (98.3)
Antibiotic prophylaxis	43 (72.7)
VUR onlast follow-up[1]	
Transient	14 (23.7)
Improved	18 (30.5)
Stable	11 (18.6)
Progressive	16 (27.1)
Hydronephrosis on last follow-up[1]	
Improved	8 (13.6)
Stable	38 (64.4)
Progressive	13 (22.0)
Bladder deformity on last follow-up[1] (n=58)	
Improved	12 (20.7)
Stable	32 (55.2)
Progressive	14 (24.1)
Time interval from 1st VUR to last follow-up[2] (month)	33 (19-64, 12-108)

CIC, clean intermittent catheterization; VUR, vesicoureteral reflux
[1]Number (%); [2]median (IQR, range)

deformity progressed from grade 1 to 3.

Follow-up VUR was categorized into 2 groups (good vs poor outcomes). Bivariate associations between variables and outcomes of VUR are shown in Table 4. Patients with low bladder compliance showed significant association with poor outcome. High detrusor pressure (Pdet > 40 cmH_2O)

Table 4. Bivariate associations with outcomes of VUR

Factors	Good outcomes (n=32)	Poor outcomes (n=27)	*p*-value
Age at onset of SCI[1]	35.1 (17.4)	40.9 (18.2)	0.22
Age at onset of VUR[1]	37.25 (17.33)	44.04 (17.65)	0.14
Gender[2]			0.61
Male	27 (84.4)	24 (88.9)	
Female	5 (15.6)	3 (11.1)	
Level of spinal cord injury[2]			
Cervical-T9	12 (37.5)	10 (37.0)	0.58
T10-L2	15 (46.9)	10 (37.0)	
L3-Sacral	5 (15.6)	7 (25.9)	
Completeness of lesion[2]			
Incomplete	8 (25)	12 (44.4)	0.12
Complete	24 (75)	15 (55.6)	
Ambulatory[2]			
Yes	7 (21.9)	6 (22.2)	0.97
No	25 (78.1)	21 (77.8)	
Time interval from SCI to VUR[3]	13.5 (10-34.5)	25 (7-44)	0.48
Duration of follow-up[3]	34 (19-63)	26 (18-66)	0.64
Bladder management before VUR[2]			
Triggered reflex voiding with incontinence	6 (18.8)	6 (22.2)	0.91
Void + CIC	3 (9.4)	3 (11.1)	
Indwelling catheterization	23 (71.9)	18 (66.7)	
Antimuscarinic medication[2]			
Yes	6 (18.8)	8 (29.6)	0.33
No	26 (81.3)	19 (70.4)	
UTI[2]			
Yes	27 (84.4)	23 (85.2)	0.93
No	5 (15.6)	4 (14.8)	
Upper tract calculi[2]			
Yes	2 (6.3)	0	0.19
No	31 (93.8)	27 (100)	
Pdet > 40 cmH_2O[2]	n=19	n=20	
Yes	8 (42.1)	14 (70)	0.08
No	11 (57.9)	6 (30)	
Low bladder compliance[2]	n=19	n=20	
Yes	11 (57.9)	18 (90)	0.02*
No	8 (42.1)	2 (10)	
Cystometric capacity < 200 mL[2]	n=19	n=20	
Yes	7 (36.8)	10 (50)	0.41
No	12 (63.2)	10 (50)	
Hydronephrosis[2]			
Yes	7 (21.9)	8 (29.6)	0.5
No	25 (78.1)	19 (70.4)	
VUR side[2]			
Unilateral	17 (53.1)	20 (74.1)	0.1
Bilateral	15 (46.9)	7 (25.9)	
VUR grading[2]			
Grade I	6 (18.8)	7 (25.9)	0.8
Grade II	5 (15.6)	3 (11.1)	
Grade III	16 (50)	13 (48.2)	
Grade IV	2 (6.3)	3 (11.1)	
Grade V	3 (9.4)	1 (3.7)	

VUR vesicoureteral reflux; CIC, clean intermittent catheterization; UTI, urinary tract infection

[1]Mean (SD), [2]number (%), [3]median (IQR); * statistic significance

Table 4. Bivariate associations with outcomes of VUR (continuted)

Factors	Good outcomes (n=32)	Poor outcomes (n=27)	*p*-value
Bladder deformity[2]	n=31	n=27	
Low grade (grade 0-1)	20 (64.52)	16 (59.26)	0.68
High grade (grade 2-3)	11 (35.48)	11 (40.74)	
Bladder management post VUR[2]			
Voluntary voiding with continence	1 (3.1)	0 (0)	0.33
Triggered reflex voiding with incontinence	1 (3.1)	4 (14.8)	
Void + CIC	2 (6.3)	2 (7.4)	
Indwelling or suprapubic catheterization	28 (87.5)	21 (77.8)	
Antimuscarinic medication after VUR[2]			
Yes	31 (96.9)	27 (100)	0.35
No	1 (3.1)	0	
Antibiotic prophylaxis after VUR[2]			
Yes	23 (71.9)	20 (74.1)	0.85
No	9 (28.1)	7 (25.9)	

VUR vesicoureteral reflux; CIC, clean intermittent catheterization; UTI, urinary tract infection
[1]Mean (SD), [2]number (%), [3]median (IQR)

tends to have poor outcome but does not reach statistical significance. Indwelling catheterization and antibiotic prophylaxis to manage VUR did not show significant difference in outcomes. Focusing on 18 patients who did not use indwelling catheterization before VUR was detected, 12 cases used indwelling catheterization and 6 cases used the same methods after VUR was detected. In the group that changed to indwelling catheterization, there were 6 patients with good outcomes and 6 patients with poor outcomes. In the group that used the same methods, there were 3 patients who had good outcomes and 3 patients who had poor outcomes. Forty-five patients who did not receive antimuscarinics before VUR was detected; 44 patients were prescribed this medication after VUR was detected. There were 25 patients who had good outcomes and 19 patients who had poor outcomes.

Discussion

VUR is one of the most common urological complications following SCI which may lead to upper urinary tract (UUT) deterioration. In Thailand, the prevalence of VUR has been reported at 11-24%.[10-12] In this study, almost all cases of VUR developed within 4 years, consistent with previous studies.[6,7,10,11] However, it could be as short as only 2 months after SCI or as long as 15 years.The Canadian Urological Association guideline recommended that urological evaluation of a patients with a newly acquired SCI should occur within 3-6 months of SCI.[21] The median time interval from SCI to VUR in this study was 19 months (IQR 10-37). Half of the patients had VUR on initial urological evaluation. Early urological management and regular urological evaluation should be performed in SCI patients.

Bladder management in our SCI patients before VUR was diagnosed consisted mainly of indwelling catheterization (69.5%) and triggered reflex voiding with incontinence (20.3%). Indwelling catheterization could not prevent VUR and may instead be the cause of VUR. After VUR was diagnosed, bladder management was switched to indwelling catheterization (83.1%). But it could not prevent VUR progression, which was consistent with previous studies.[6,7] Five patients with VUR used triggered reflex voiding with incontinence and 4 patients used voiding plus CIC. No significant correlation between type of bladder management and VUR outcome was found in this study. Improper bladder management and late urological evaluation in post-acute SCI rehabilitation service remain the problem. It can be challenging to have early urological evaluation and switch the patients from indwelling catheterization and triggered reflex voiding with incontinence to CIC.

Antibiotic prophylaxis was a common means of management for VUR in this study (72.7%); patients with VUR have a high risk of UTI.[22] However, there is still a lack of evidence for its efficacy in adults with SCI. Research in pediatrics, for which there is an extensive body of research in continuous antibiotic prophylaxis, still shows conflicting results.[4,5,8,9] In this study, no association was found between antibiotic prophylaxis and VUR outcome consistent with a previous study in Thailand.[10] Antimuscarinics were prescribed for only 23.7% of cases at the time VUR was diagnosed; but most patients (98.3%) received some after that. We could not find any effect of antimuscarinics on VUR outcome in bivariate analysis.

Detrusor overactivity and bladder compliance were associated with UUT deterioration in many studies.[13,17,23,24] However, in the present study showed that only half ofVUR patients had detrusor overactivity (NDO) (Pdet > 40 cmH_2O), 74.4% had low compliance, and 43.6% had low bladder capacity (< 200 mL). The etiology of VUR in SCI patients ramains unclear. However, there are two etiologies of VUR in SCI patients: primary and secondary.[25] Primay reflux is a congenital anomaly of the ureterovesical junction. One recent study showed 11 of 15 SCI patients with VUR had

congenital displaced ureteral orifices.[25] Secondary reflux is secondary to bladder deformity and loss of bladder compliance leading to anatomic changes, resulting in lack of support of the posterior bladder wall musculature. In this study, no single etiology of VUR was found. We tried to invesigate the factors affecting the outcome of VUR after management. Bladder compliance is the only one factor which had a statistically significant association with the outcome of VUR on long-term follow-up. As mentioned before, there is no single etiology. The keys to improving VUR outcomes are to maintain low detrusor pressure, preservation of adequate bladder capacity and compliance[26] and prevention of recurrent UTI.[22,26]

VUR after conservative management resulted in good outcomes in half of the patients without causing damage to the UUT; this was consistent with a previous study.[22] Poor VUR outcome was not directly associated with UUT deterioration or impared renal function. Less than 20% of VUR patients had impaired renal function, and it did not correlate with VUR progression. The patient who had CKD stage 5 and who was on hemodialysis developed VUR on the first urological check-up and had no VUR on the next evaluation. The results also showed that about half of the patients who had impaired renal function had transient or improvement of VUR on follow-up. Whereas, almost all of the patients were stable and progressive on ultrasound and bladder deformity. We could not clearly explain these findings. Accurate detection of VUR depends on the radiologist, consistent with a previous study, which found that the grading system of VUR varies among doctors especially in middle grades (grade III and IV).[27] The technique of refilling the contracted bladder with contrast medium in SCI patients may be one of the reasons. Because no antireflux surgery was performed in this SCI population, we could not discuss about its efficacy or complications. Previous studies showed good results after surgery.[6,22] However, Wu CQ reported that secondary VUR in NLUTD is less likely to be cured with antireflux surgery independent of technique or surgical approach.[26]

There is a sparse consensus on the urological evaluations in SCI patients.[28] Previous studies recommended yearly ultrasound of upper and lower urinary tract which has a good sensitivity for diagnosing upper tract problems and stones. It is a useful, noninvasive, has no radiation exposure, and is a cost-effective method for routine and long-term follow-up.[28] Bladder deformity and trabeculation from VCUG or cystography were associated with UUT deterioration in previous studies.[12,20] In this study, we found that VUR and hydronephrosis or bladder deformity did not correlate well in all patients. About half of SCI patients with impaired renal function showed VUR improvement on follow-up, the same patients also had worse hydronephrosis and bladder deformity. Not only should the grading of VUR be focused, the shape and trabeculation of bladder and hydronephrosis should be included in urological investigations in SCI patients with VUR. Urodynamic study gives a useful information for proper bladder management and medication. It should be performed at the time of initial evaluation and repeated as appropriate.[21] We did not perform urodynamics in every SCI patients with NLUTD but in recent years the rate of urodynamics/cystometry has been increased in our department. Urodynamics/cystometry was performed in 75% of patients in this study compared to 37.4% in the previous research at the same hospital.[10] Level of SCI, completeness of lesion, ambulatory level did not predict VUR development[10] or progression. Every SCI with NLUTD should have a regular urological check-up to detect early UUT deterioration and ensure proper management.[28-30]

There were some limitations of this study. Firstly, no UTI frequency, urinalysis, or pathogens were recorded. Because UTI is an important factor correlated with VUR and may be a cause of VUR,[22,26] more details of UTI should be investigated in future researches. Secondly, the small number of patients means comparisons between the 2 groups could not reach statistical significance or may not be reliable. Thirdly, urodynamics/cystometry was not performed in the same period that VUR was detected and not every patient had results; it may be interfered with data analysis. Lastly, this study included patients with at least one year follow-up, some of them only had data from two urological check-ups for comparison. A longer follow-up period of is suggested in the future.

In conclusion, VUR remains an important complication in SCI patients, leading to UUT deterioration. About half of VUR were improved after conservative treatment. Bladder compliance was a factor associated with VUR outcome. Indwelling catheterization or antibiotic prophylaxis did not prevent progression of VUR. Early urological management and regular urological evaluation should be performed in SCI patients.

Disclosure

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