Neurogenic Bladder and Urodynamic Outcomes in Patients with Spinal Cord Myelopathy

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Background: Urodynamics (UDs) are routine in traumatic spinal cord injury (SCI), but there are few reports regarding nontraumatic spinal cord myelopathy (SCM) patients. **Purpose:** To describe the neurogenic bladder and UD outcomes in SCM patients and determine whether the UD recommendations result in clinically important changes to bladder management. **Methods:** This retrospective case study examined a series of SCM patients admitted to a spinal rehabilitation service who underwent UD between January 1, 2000 and June 30, 2010. **Results:** Sixty-five UD tests were performed a median of 7 months post SCM. Most ($n = 34$; 57%) patients were male, and the median age was 60 years. Most patients ($n = 46$; 77%) were paraplegic and were continent of urine ($n = 38$; 58%). Thirty-five (46%) patients voided on sensation, 26 (40%) performed intermittent self-catheterization, and 9 (14%) had an indwelling catheter. The most common UD finding was overactive detrusor with no dysynergia ($n = 31$; 48%), followed by overactive detrusor with sphincter dysynergia ($n = 16$; 25%) and detrusor areflexia/underactive ($n = 12$; 18%). Key UD findings were median cystometric capacity 414 mL (interquartile range [IQR], 300-590), median maximum detrusor contraction 49.5 cmH₂O (IQR, 25-85), and median residual volume post voiding 100 mL (IQR, 5-200). The recommendations for changes to bladder management following UD resulted in clinically important changes to existing strategies in 57 studies (88%). **Conclusions:** Future studies should ascertain whether our screening protocol is appropriate, and a longer-term follow-up should examine the relationship between UD recommendations and prevention of complications. **Key words:** neurogenic bladder, outcome assessment (health care), spinal cord diseases, urodynamics

Neurogenic lower urinary tract dysfunction is a common complication following spinal cord damage.^{1,2} It is associated with an increased risk of long-term complications, such as urinary incontinence, urinary tract infection, urinary reflux, hydronephrosis, and renal impairment.³ The consequences of neurogenic bladder can interfere with patients' activities of daily living, community integration, participation in social roles, and quality of life. Recent reviews highlight the goals of bladder management after spinal cord damage and current management options.^{2,4} Urodynamics (UDs) is the accepted gold standard⁵ for the evaluation of neurogenic bladder in patients with traumatic spinal cord injury (SCI) to identify subclinical problems, such as detrusor

dysreflexia, that cannot be detected by clinical examination alone.⁶

Most patients with traumatic SCI are managed in dedicated spinal units⁷ where they are able to access UD. Patients with nontraumatic spinal cord myelopathy (SCM) – caused by conditions such as malignancy, infections, degenerative conditions resulting in cord compression, and spinal cord infarction⁸ – are typically managed in a wide range of settings and are much less likely to be admitted to a specialist spinal rehabilitation unit.^{9,10} These patients tend to have reduced access to specialist programs and services recommended for patients with spinal cord damage, including UD.^{10,11} SCM patients tend to be much older than those with traumatic SCI.⁷⁻⁹ As a result,

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they may have premorbid urological conditions that can influence their bladder management during rehabilitation and subsequent community integration. Despite reports suggesting that the incidence of SCM is greater than traumatic SCI in developed countries,^{12,13} there have been very few studies describing the urological outcomes for patients with SCM.¹⁴⁻¹⁶ Therefore, research on the bladder and urological outcomes for patients with SCM is important to help guide the management of these patients.

The primary objective of this project was to study the neurogenic bladder functioning and UD findings in patients admitted to a spinal rehabilitation service with a diagnosis of SCM. The secondary objectives were to assess whether the recommendations made following UDs resulted in a clinically important change to the patient's bladder management and to determine whether the recommendations made as a result of the UDs were followed.

Methods

We conducted a retrospective study of patients with a recent onset of SCM who were admitted to the Spinal Rehabilitation Service between January 1, 2000 and December 31, 2009. Patients who subsequently underwent UDs, either during their rehabilitation admission or subsequently as an outpatient (until June 30, 2010), had details extracted from their medical file regarding a range of clinical, demographic, and bladder outcomes, with a focus on UDs. As this was an exploratory study, there was no predetermined sample size.

Study population and design

The Spinal Rehabilitation Service at Caulfield Hospital, Victoria, Australia, is a 12-bed adult inpatient unit. It is located in a public hospital and funded by the State, but patients are admitted from both private and public hospitals after they are deemed medically and surgically stable.

The approach taken by the Spinal Rehabilitation Service in deciding whether to refer patients for UDs was based on a number of determinants. Persons who were perceived to be at highest risk of urinary tract abnormalities where UDs could guide a change in management were the highest priority.

Examples include individuals who perform self-intermittent catheterization or who have a postvoid residual urine volume higher than 200 mL. Patients with an indwelling catheter (urethral or suprapubic) were not usually referred unless they experienced catheter bypassing unrelated to the blockage of the catheter or recurrent infections in the absence of urinary calculi. Patients who experienced bladder recovery and were able to void on sensation with low postvoid residual urine volume (generally <100 mL) and no episodes of incontinence (unrelated to mobility) or urinary tract infection were also not usually referred for UDs.

Patients with recent onset of SCM admitted to the Spinal Rehabilitation Service who underwent UDs, either during their initial rehabilitation admission or subsequently as an outpatient, were included in this study. The International Continence Society guidelines on UDs were followed when carrying out this procedure.¹⁷ The results from patients who underwent UDs at other centers following discharge were also included. Patients with congenital causes for SCM and those with multiple sclerosis were excluded, because both these patient groups have UD outcomes documented in previous studies. In addition, those with multiple sclerosis could have voiding dysfunction due to cortical lesions and the congenital group did not have a recent onset of SCM.

Materials

Anticholinergic agents were usually discontinued 2 to 3 days prior to UDs, and urinary tract infection was excluded by urine culture. A computer-assisted video-urodynamic unit (Laborie, Canada) was used. Patients were positioned in a standing position, if tolerated; otherwise they were supine and, if tolerated, the table was tilted. Without gravity there is a tendency for the contrast used in UDs to spread in a way that obscures the bladder on the video screen. A view of the bladder in a recumbent position does not reveal as much as in a standing position. The bladder was filled and the intravesical pressure was recorded via a transurethral twin-lumen UD catheter for cystometry (8 channel). The filling rate was 10 to 60 mL/min, depending on whether the patient had an upper motor or lower motor neuron lesion. Abdominal pressure

was registered by a rectal balloon catheter. Sterile saline solution at body temperature was used for filling the bladder until the detrusor leak point was reached or the patient experienced a sensation that would normally lead to the immediate need to void. In patients with poor or no bladder sensation, filling was continued until the functional bladder capacity of at least 500 mL was reached.

Fluoroscopic examination of the upper urinary tract during voiding attempts was performed routinely to identify evidence of vesico-ureteric reflux or hydronephrosis. Detrusor sphincter dysynergia was diagnosed by the use of fluoroscopy and elevated detrusor pressure and, when present, an urge to void but absent, poor, or intermittent voiding. Electromyography was not available. Discussions with colleagues indicate that similar methods for performing UD were used at other centers, but the specific manufacturer's details of the equipment was not recorded.

Outcomes variables

The variables of interest included demographic characteristics, etiology of SCM categorized according to the basic level-2 classification described in the International Spinal Cord Injury Data Sets for Non-Traumatic Spinal Cord Injury,¹⁸ level of injury (paraplegia vs tetraplegia), and the American Spinal Injury Association Impairment Scale (AIS) grade of injury.¹⁹ We dichotomized the grade of injury into motor complete (AIS grade A) and motor incomplete (AIS grade B, C, or D). We also recorded the presence of any premorbid bladder problem, the continence status at the time of UD, the nature of bladder management, and the results of the UD.

The recommendations for bladder management following the UD testing were recorded. An appraisal was made as to (a) whether the recommendations for bladder management following UD resulted in changes that were clinically important, and (b) the extent to which the UD recommendations were followed, as documented in the file notes at 6 to 12 months following UD, and any mitigating factors. We made these determinations in a nonblinded discussion, reflecting the approach taken at our institution when recommendations are made following UD. The Spinal Rehabilitation Service

and Continence Service has a multidisciplinary team meeting that includes the continence nurse who assists with the UD, a urologist, the aged-care physicians who perform the UD (including L.D.), and the head of the Spinal Rehabilitation Service (P.W.N.). The results from the UD are reviewed in the context of the clinical, functional, social, cognitive, and emotional state of the patient before final recommendations are documented. On this basis, we felt that it was appropriate for this study to use a similar consensus approach to determining whether the UD recommendations resulted in clinically significant changes and whether there was compliance with the recommendations. For disagreements that could not be resolved by discussion, we planned for the final determination to be made by the urologist working in the continence service.

Statistical analysis

Analysis was performed using Stata version 11 (StataCorp, College Station, Texas). Descriptive analysis was performed where appropriate, including median and interquartile range (IQR) for variables not normally distributed. The relationship between categorical variables was assessed using the chi-square test with the Fisher exact correction because of small numbers. The Kruskal-Wallis test was used to compare numerical data between groups.

P values $\leq .05$ were deemed statistically significant. We certify that all applicable institutional and governmental regulations concerning the ethical use of humans were followed during the course of this research. Approval for this project was obtained from the local human research ethics committee.

Results

Over the study period, there were 318 patients with recent onset of SCM admitted to the unit. Of these, 60 (18.9%) had 65 UD performed (5 patients had 2 studies). The median age of patients was 60 years (interquartile range [IQR], 41-74; range, 18-89). The clinical and demographic characteristics of patients, including premorbid bladder dysfunction, are shown in **Table 1**.

Table 1. Clinical and demographic characteristics of spinal cord myelopathy patients undergoing urodynamics

Characteristics	n (%)
Male	34 (57)
Etiology	
Vertebral column degenerative disorders	16 (27)
Tumor (benign or malignant)	8 (13)
Vascular-infarction	11 (18)
Vascular-hemorrhage	5 (8)
Infection	8 (13)
Inflammation	10 (17)
Other	2 (3)
Level	
Paraplegia	46 (77)
Tetraplegia	14 (23)
Neurological category	
T6 or above	32 (53)
T7-T12	13 (22)
Cauda equina	15 (25)
AIS grade	
A	4 (7)
B	6 (10)
C	22 (37)
D	28 (47)
Premorbid bladder dysfunction	16 (27)
TURP	7 (12)
BPH	3 (5)
Incontinence unrelated to SCM	5 (8)
Nocturia	3 (5)
Other	1 (2)

Note: AIS = American Spinal Injury Association Impairment Scale; BPH = benign prostatic hypertrophy (no surgery); SCM = spinal cord myelopathy; TURP = transurethral resection of prostate.

Most patients were continent of urine at the time of UD (n = 38; 58%). The strategies used by patients for the management of their incontinence included nil (n = 6), pads (n = 14), and medications (n = 17). Thirty-five (46%) patients were voiding on sensation, 26 (40%) were performing intermittent self-catheterization, and 9 (14%) had an indwelling catheter. UD were performed a median of 7 months (IQR, 4-12; range, 2-84) following the onset of SCM and most (n = 54; 83%) were performed at our hospital. The results of the pre-urodynamic assessment and UD results are shown in **Table 2**. Six patients were taking anticholinergic agents at the time of the UD, and the UD were performed to confirm adequate reduction in detrusor pressure.

The most common UD finding was overactive detrusor with no dysynergia (n = 31; 48%),

Table 2. Pre-urodynamic voiding and urodynamic results in spinal cord myelopathy patients

Voiding and results	Median (IQR) or n (%)
<i>Pre-urodynamic voiding</i>	
Peak flow rate, mL/s	10 (8-17.5)
Voiding time, seconds	25 (19-43)
Volume voided, mL	111.5 (83-186)
Residual volume, mL	100 (30-200)
<i>Urodynamic results</i>	
Bladder filling first sensation, mL	207 (135-347.5)
First desire, mL	225 (145-360)
Cystometric capacity, mL	414 (300-590)
Involuntary bladder contraction	45 (69)
Leakage with bladder contraction	37 (57)
Volume first contraction, mL	248.5 (155-402)
Maximum detrusor contraction, cmH ₂ O	49.5 (25-85)
Voiding peak flow, mL/s	9 (7-16)
Voiding peak pressure, cmH ₂ O	40 (22-60)
Voiding time, seconds	38 (22-70)
Volume voided, mL	185 (111.5-300)
Residual volume post voiding, mL	100 (5-200)
Hydronephrosis visualized	1 (1.5)
Bladder trabeculation or diverticulum visualized	21 (32)
Ureteric reflux demonstrated	3 (5)
Stress incontinence	19 (29)
Poor bladder capacity	29 (45)
Poor compliance	36 (55)
High residual	33 (51)
Reduced flow rate	43 (66)

Note: IQR = interquartile range.

followed by overactive detrusor with sphincter dysynergia (n = 16; 25%) and detrusor areflexia/underactive (n = 12; 18%). Two (3%) studies were reported as normal and 4 (6%) had other findings. There was no significant relationship between the UD diagnosis and the following: age (Kruskal-Wallis, $\chi^2 = 3.5$, $P = .2$), gender ($\chi^2 = 3.3$, $P = .2$), level of injury ($\chi^2 = 3.7$, $P = .2$), completeness of SCM ($\chi^2 = 0.5$, $P = .7$), or the occurrence of urinary incontinence ($\chi^2 = 1.5$, $P = .5$). Key UD results and voiding method by type of neurogenic bladder are shown in **Table 3**.

The recommendations for neurogenic bladder management following UD included the following: bladder retraining (n = 12; 18%), good bladder habits (n = 12; 18%), trial of anticholinergic medication (n = 29; 45%), adjustment in dose of current medication (n = 15; 23%), discontinuation of anticholinergic medication (n = 6; 9%), trial of

Table 3. Voiding method by type of neurogenic bladder and key urodynamic results

Voiding method and results	Detrusor areflexia (<i>n</i> = 12; 18%)	Overactive detrusor without dysynergia (<i>n</i> = 31; 48%)	Overactive detrusor with dysynergia (<i>n</i> = 16; 25%)	<i>P</i>
Voiding method, <i>n</i> (%)				
No catheter	7 (58)	26 (84)	7 (44)	$\chi^2=10.5, P=.02$
Intermittent catheter	3 (25)	2 (6)	7 (44)	
ICD/SPC	2 (17)	3 (10)	2 (12)	
Median (IQR) cystometric capacity, mL	545 (415-700)	330 (215-500)	335 (170 -600)	$\chi^2=7.7, P=.02$
Median (IQR) maximum detrusor contraction, cmH ₂ O	19 (15-25)	49 (29-73)	75 (30-110)	$\chi^2=4.9, P=.09$
Median (IQR) residual volume post voiding, mL	52.5 (0-250)	100 (75-200)	55 (5-200)	$\chi^2=1.1, P=.6$

Note: ICD/SPC = indwelling catheter or suprapubic catheter; IQR = interquartile range.

alpha-antagonists (*n* = 5; 8%), pelvic floor exercises (*n* = 6; 9%), biofeedback (*n* = 2; 3%), and referral for cystoscopy (*n* = 10; 15%) or an opinion regarding other surgical procedures (*n* = 10; 15%).

In 57 of 65 studies (88%), clinically important changes to existing bladder management strategies were made. In the assessment of compliance with these recommendations, information was available in 49 (75%) studies. Of these, it was determined that in most patients (*n* = 21; 43%), the recommendations were fully followed; in 18 (37%), they were partially followed; in 8 (16%), they were noncompliant; and in 2 cases (4%), it was unclear.

Discussion

Many patients had major bladder and UD abnormalities, despite many patients voiding on sensation or being catheter-free. The recommendations based on the UD findings in our patients often resulted in clinically important changes to previous management strategies. Overall, there was reasonable compliance with the neurogenic bladder management recommendations at 6 to 12 months follow-up.

The demographic and clinical characteristics of our sample were consistent with previous reports of patients with SCM.⁷⁻⁹ Compared to patients with traumatic SCI,²⁰ the UD results from our study suggest that SCM patients may have an increased cystometric capacity, reduced maximum detrusor pressure, increased volume voided, and a reduced

postvoid residual volume. The type of neurogenic bladder appeared to influence the voiding method and cystometric bladder capacity, but no other UD outcomes. Previous studies of UD outcomes that included SCM patients are not useful for comparison with our results because they did not report findings for SCM patients separately.^{14,15} SCM results in spinal cord damage that tends to be more incomplete compared with traumatic SCI; because there are more spinal pathways preserved, this can help improve the bladder functioning.

Our findings illustrate that in SCM patients, as in traumatic SCI patients,⁶ it is not appropriate to rely on empirical bladder management without UDs, particularly in patients at higher risk of abnormalities, such as those in this study. Increased intravesical pressure, which is responsible for major adverse consequences in neurogenic bladder, can be clinically silent. Furthermore, a low postvoid residual urine volume or absence of urinary incontinence does not guarantee against urological complications.²¹

The strength of our study is that it specifically focused on SCM. We assessed the utility of UDs and found that they very often resulted in clinically important changes to patients' bladder management. Furthermore, we found that the compliance with recommendations was generally very good. These findings and the range of neurogenic bladder and urodynamic outcomes in SCM patients have not been previously reported.

It is not known to what extent our results can be generalized to other SCM patients. The

limitations of our study include its retrospective study design and selection bias. Not all patients with SCM admitted to the unit had UD; only those considered at highest risk of urological problems were selected. This approach, however, was a pragmatic one that mirrored clinical practice. Due to resource constraints, it was not possible during the study period to offer UD to all patients with SCM or to arrange for UD to be performed in a timelier manner. The findings from this study regarding patients having major UD abnormalities that were not clinically recognized suggest that efforts should be made to address this resource constraint. The study only included patients admitted to a single center, however, our unit is the major site of rehabilitation for patients with SCM in the State. Also, the results included UD that were performed at other clinics. Post hoc testing (results not reported) did not indicate a significant difference in clinical or UD results between our center and others. Patients were routinely monitored for autonomic dysreflexia and episodes did occur, however we did not record this information during the data extraction from the medical files. The sample size was not adequately powered to detect differences in the subgroup analyses; because this was an exploratory study, we believe this was appropriate. The use of electromyography would have been an advantage in confirming overactive detrusor with sphincter dysynergia, but it was not performed in our present study. Furthermore, our UD were usually the initial testing performed; it is not known to what extent the management strategies recommended were successful at reducing the high detrusor pressure found in many patients. The follow-up of outcomes was incomplete, limited to 6 to 12 months, and not able to include complications such as urinary tract infections because of incomplete documentation.

Further study of the neurogenic bladder and UD outcomes of SCM patients is needed. Ideally, these studies should be prospective and include

all SCM patients sooner after the onset of SCM to determine whether the screening protocol is appropriate, include larger numbers of patients to give adequate power to detect differences between the subgroups, and conduct a more complete long-term follow-up to enable determination of relationship between UD recommendations and prevention of complications. It would also be ideal if electromyography recordings were performed during UD to help confirm detrusor sphincter dysynergia. Multicenter studies would facilitate the more timely completion of this research. Studies of long-term annual UD in SCM patients should be conducted to determine whether these patients have need for changing bladder management, as has been reported in patients with traumatic SCI.²²

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