

# Urodynamic profile of patients with neurogenic bladder following non-traumatic myelopathies

Anupam Gupta, Arun B Taly<sup>1</sup>

Department of Neurological Rehabilitation, <sup>1</sup>Department of Neurology, NIMHANS, Bangalore, Karnataka, India

## Abstract

**Objective:** To observe the urodynamic profile of the patients following non-traumatic myelopathies (NTMs) with neurogenic bladder. **Setting:** Neurological rehabilitation department of university tertiary research hospital. **Materials and Methods:** Seventy-nine patients (44 men) with monophasic NTM, with the age range 8-65 years ( $31.0 \pm 16.0$  years), were admitted for inpatients' rehabilitation. Length of stay in rehabilitation ranged from 6 to 120 days ( $32.0 \pm 24.8$  days). Fifty-six patients (70.9%) had spinal lesion above D10, 17 had lesion between D10 and L2 (21.5%), and 6 (7.6%) had cauda equina syndrome. All patients had neurogenic bladder with urinary complaints. Urodynamic study (UDS) was performed in all patients. **Results:** UDS showed 71.4% patients (40/56) had neurogenic detrusor overactivity (NDO) with or without sphincter dyssynergy (DSD) with lesion above D10; only 52.9% patients (9/17) had NDO with or without DSD detrusor with lesion between D10 and L2; and majority (5/6 patients) had underactive detrusor in the cauda equina group. Bladder management was based on the UDS findings. No significant correlation was found ( $P > 0.05$ ) between detrusor behavior and the level, severity (ASIA Impairment Scale) of spinal injury, or gender using chi-square test. **Conclusions:** Neurogenic bladder following NTM was observed in all patients. UDS suggested predominantly NDO in lesions above D10 and mixed pattern in between D10 and L2 lesions. No significant correlation was found between detrusor behavior and the level or severity of NTM in the study.

## Key Words

Neurogenic bladder, non-traumatic myelopathies, urodynamic study

## For correspondence:

Dr. Anupam Gupta, Department of Neurological Rehabilitation, NIMHANS, Bangalore – 560 029, Karnataka, India.  
E-mail: drgupta159@yahoo.co.in

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## Introduction

Spinal cord lesions are well known to cause neurogenic bladder dysfunction.<sup>[1]</sup> Significant association exists between the level of spinal cord lesion and its correlating bladder and sphincter behavior. Lesions above the spinal micturition center may lead to neurogenic detrusor overactivity (NDO) and detrusor-sphincter dyssynergia (DSD), inducing reflex micturition with increased detrusor leak point pressures, causing incontinence and consequent renal damage if untreated.<sup>[2,3]</sup>

The role of urodynamic study in assessment and management of neurogenic bladder following myelopathies is well established. A number of studies in the past have reported the

significance of such a practice to manage bladder effectively following non-traumatic myelopathies (NTMs) and to avoid complications in lower and upper urinary tract in the short- and long-term run.<sup>[4-16]</sup>

The present study was conducted to observe detrusor behavior in patients following monophasic NTM (a spinal disorder/lesion with a single phase) by performing urodynamic study (UDS) and to manage bladder accordingly. Another objective was to see if there is any correlation between detrusor behavior according to UDS and the level and severity of spinal cord lesion in these patients.

## Materials and Methods

This observational study was conducted in the neurological rehabilitation department of university tertiary research hospital. All NTM patients admitted for inpatient rehabilitation between January 2008 and December 2010 were included in the study. Institute's ethics committee approved the project. Patients with only NTMs, monophasic spinal lesion (including cauda equina syndrome), giving consent to participate in the study, admitted for the first time after the injury, and undergoing UDS were included. Patients with traumatic

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spinal cord injury, recurrent myelopathies, multiple sclerosis with spinal lesion, patients with readmission after NTM, and patients having no urinary complaints (bladder diary and abdominal ultrasound also suggestive of no leaks and no post void residual) and doing voluntary micturition were excluded from the study.

Seventy-nine patients (44 men) fulfilling the criteria were included. Detailed clinical neurological examination of patients was done. Upper level of spinal lesion was determined by magnetic resonance imaging (MRI) scan findings and recording was made. Severity of injury was determined using ASIA Impairment Scale (AIS). Functional disability was assessed using Barthel Index (BI) scale. Both scales were used at admission and discharge to assess the recovery during inpatient rehabilitation. Length of stay (LOS) in the rehabilitation unit and duration of illness till the time of admission in the unit were also recorded. Indwelling catheters were removed in all patients after admission and bladder diary was maintained to observe the neurogenic bladder pattern. Patients had urgency/urge incontinence or obstructive urinary complaints, with some of them having stress incontinence also.

UDS was performed in all the patients using multichannel pressure recording technology with Life-Tech. (USA) equipment Primus following International Continence Society guidelines.<sup>[17-19]</sup> Filling cystometry was performed with the patients in supine position on the urodynamic table. Bladder filling was done with normal saline at medium fill rate. All recordings were made during the procedure (both filling and voiding phase). Sphincter electromyography was performed in all patients to observe DSD. The bladder management was based on the UDS findings. Statistical analysis of the data was done to observe correlation between detrusor (bladder) behavior according to UDS and the level of spinal injury. We also tried to correlate detrusor behavior with severity of spinal injury and gender.

### Data analysis

Analysis was done using SPSS 15.0 version. Descriptive statistics included frequency, means, and standard deviation for quantitative variables such as age, duration of illness, duration of stay, level of injury, urinary complaints, UDS findings, and BI scores.

Paired Student's *t*-test was used for the assessment of functional recovery using mean BI scores at admission and discharge. The Wilcoxon non-parametric test was used for the assessment of neurological recovery by comparing admission and discharge ASIA scale scores. Chi-square test was used to observe correlation of detrusor behavior with spinal level of injury, gender, and severity of spinal injury.

### Results

Seventy-nine patients (M:F = 44:35) were included in the study. Mean age of the study cohort was 31 years (range 8–65 years, SD 16.0 years). Mean duration of illness at the time of admission in rehabilitation unit was 2.0 months (range 1–48 months, SD 10.6). Mean length of stay in the unit for inpatient rehabilitation was 32 days (range 6–120 days, SD 24.8).

The etiology of NTM is given in Table 1.

Fifty patients (63.3%) had paraplegia/paresis, whereas 29 patients (36.7%) had quadriplegia/paresis. Fifty-six patients (71%) had upper level of lesion above D10, 17 patients (21.5%) had lesion between D10 and L2, and 6 patients (7.6%) had cauda equina syndrome. Pattern of onset of illness was: acute (within 24 h) in 9 patients (11.4%), sub-acute ( $\leq 1$  week) in 31 (39.2%), progressive ( $> 1$  week) in 11 (13.9%), and chronic ( $> 1$  month) in 28 patients (38.4%).

Twenty patients (25%) had obstructive urinary complaints like hesitancy, straining to void, and incomplete evacuation, whereas 57 patients (72.2%) had urinary complaints in the form of increased frequency, urgency, and urge incontinence. Two patients had mixed complaints with stress incontinence also.

UDS findings suggested the following: 30 patients (38%) had NDO without DSD, 20 patients (25.3%) had NDO with DSD, underactive detrusor was present in 25 patients (31.6%), and 4 patients (5.1%) had normal study.

The correlation of UDS findings with level of spinal injury is shown in Table 2.

UDS findings showed majority of the patients had significant post-void residual [71/79 (89.9%)], whereas 7 patients had no post-void residual. The bladder management advice

**Table 1: Etiology of non-traumatic myelopathy**

Etiology	No. of patients	Percentage
PIVD/spondylitic myelopathy	12	15.2
Tumor – benign	12	15.2
Tumor – malignant	5	6.3
Vascular – hemorrhagic	1	1.3
Vascular – malformation	5	6.3
Acute transverse myelitis	27	34.2
Infection – tuberculosis	11	13.9
Infection – others	2	2.6
Syrinx	2	2.6
Toxic	2	2.6
Total	79	100%

PIVD=Prolapsed intervertebral disc

**Table 2: Correlation between urodynamic study findings and the level of spinal injury**

Level of injury	Urodynamic study				Total
	Normal study	NDO without DSD	NDO with DSD	Underactive detrusor	
Cervical	1	12	8	8	29
Dorsal (D1–D9)	2	13	7	5	27
Dorsolumbar (D10–L2)	1	4	5	7	17
Cauda equina syndrome	0	1	0	5	6
Total	4	30	20	25	79

NDO=Neurogenic detrusor overactivity, DSD=Detrusor-sphincter dyssynergia

was based on the UDS findings. Forty-four patients (55.7%) were advised anti-muscarinics (tolterodin, solifenacin, propantheline, or oxybutynin) along with behavioral and supportive treatment and 8 patients (10.1%) were advised anti-muscarinics along with voluntary micturition. Eighteen patients (22.8%) were advised only clean intermittent catheterization along with fluid restriction, 7 patients (8.9%) were advised voluntary micturition, and 2 patients (2.5%) were advised anti-muscarinics, adrenergic agonists, and clean intermittent catheterization.

Functional recovery during inpatient rehabilitation was assessed using BI scale. It showed significant recovery in patients when mean discharge BI score 60.0 (range 5-100, SD 25.4) and admission scores 25.0 (range 0-80, SD 19.4) were compared using paired Student's *t*-test ( $P < 0.001$ ). Similar trend was observed with neurological recovery using AIS, with significant recovery ( $P < 0.001$ ) when admission and discharge scores were compared using Wilcoxon test [Table 3].

One of the main objectives of the study was to observe the correlation between detrusor behavior according to UDS and the level of spinal injury. In the present study, it was found to be insignificant ( $P > 0.05$ ) using chi-square test. Similarly, no significant correlation was found between bladder behavior and gender or neurological status (using AIS) [Table 4] in the study.

Out of 44 males in the study, 29 were found to have NDO with or without concurrent DSD (65.9%) and the remaining had underactive/normal detrusor. Twenty-one female patients out of 35 had NDO (60%) and the remaining had underactive/normal detrusor. Three out of four patients in the study found to have normal UDS study were females.

**Table 3: Neurological recovery with ASIA Impairment Scale (AIS)**

ASIA score	Admission	%	Discharge	%	<i>P</i> value
A	32	40.5	18	22.8	<0.001
B	0	0	1	1.3	
C	39	49.4	26	32.9	
D	8	10.1	32	40.5	
E	0	0	2	2.5	
	79	100	79	100	

**Table 4: Correlation between neurological status using ASIA Impairment Scale (admission) and urodynamic study findings**

ASIA Impairment Scale – admission	Urodynamic study				Total
	Normal detrusor	NDO without DSD	NDO with DSD	Underactive detrusor	
A	0	11	12	9	32
B	0	0	0	0	0
C	3	15	8	13	39
D	1	4	0	3	8
E	0	0	0	0	0
Total	4	30	20	25	79

NDO=Neurogenic detrusor overactivity, DSD=Detrusor-sphincter dyssynergia

## Discussion

There were slightly more male patients in the present study (55% males). Some earlier studies including one from the same center have reported female patients outnumbering males in NTM.<sup>[20,21]</sup> This is in contrast to traumatic myelopathies where male predominance and younger age with road traffic accidents as the main causal factor have been widely reported and known. Nearly two-third of the patients in the study had paraplegia [50/79 (63.3%)] with lesion in dorsal and lumbar region. This trend has been shown in some earlier studies also on NTM, with more common lesions in dorsal and lumbar region causing paraplegia. Nearly three-fifth of the patients had incomplete myelopathies (ASIA-C and -D) at the time of admission to the rehabilitation unit. As has been reported in earlier studies also, NTMs are known to cause less severe (more incomplete) myelopathies as compared to traumatic myelopathies.<sup>[20,21]</sup>

UDS following NTM (and traumatic myelopathies) has been the recommended norm. Historically, before UDS, the coupling of cystometry and sphincter electromyography allowed the clinician to accurately diagnose DSD and the mode of bladder management was chosen empirically, without reliance on objective testing. This method fails to observe clinically silent raised intravesical pressure responsible for the majority of urologic complications in patients with neurogenic lower urinary tract dysfunction.<sup>[22]</sup> The goals of proper bladder management in paralyzed patients are to keep the lower urinary tract at good capacity, low pressure, without infection, and without incontinence, which would help in the long term in preventing damage to upper urinary tracts and kidneys function.<sup>[23]</sup>

Nearly three-fourth of the patients [57/79 (72.2%)] in the study had urinary complaints in the form of increased frequency, urgency, or urge urinary incontinence, whereas only 20 patients (25.3%) had obstructive complaints with retention, hesitancy, and straining to pass urine. UDS results were inconsistent with the clinical complaints as 50 patients had NDO with or without concurrent dyssynergy, whereas 25 patients had underactive detrusor. This emphasized the importance of performing UDS for effective bladder management as the detrusor behavior is dynamic and clinical complaints of the patients may change with time, as has been shown in some other longitudinal studies.<sup>[5,10,22]</sup>

No consistent pattern was observed when comparing detrusor behavior with the severity of injury according to AIS scores. Thirty-two patients in the study (40.5%) had complete myelopathy at the time of admission in rehabilitation unit (ASIA-A). Out of these, 23 patients (72%) had NDO, whereas the remaining 9 patients had underactive detrusor. Thirty-nine patients (49.4%) had incomplete motor myelopathy (ASIA-C) of whom only 23 patients (58.9%) had NDO and the remaining 41% patients had underactive/normal detrusor pressure on UDS. Eight patients had ASIA-D lesion, with only 50% observed to have NDO and the remaining had underactive detrusor (3/4). Although UDS needs to be done in all NTM patients for effective bladder management, these findings suggest no significant correlation between detrusor behavior and the severity of

spinal lesion. Further, as the patients showing significant neurological recovery may still continue to have neurogenic bladder and vice versa, all NTM patients need to be followed up long term for effective management of bladder and to avoid complications. Correlation between detrusor behavior and severity of spinal lesion using AIS was found to be statistically insignificant ( $P > 0.05$ ).

The spinal neurological lesions have been classified as upper or lower motor neuron lesion with respect to the anatomical relationship of the lesion to the sacral cord reflex centers (S2-4). The lesions could be suprasacral (when the injury is above S2), sacral (when there is injury to sacral center), or infrasacral (when there is injury to nerve roots; cauda equina lesions). The bladder has both parasympathetic and sympathetic innervations. It is known that the spinal micturition reflex pathway is essential for the development of automatic voiding after myelopathies and that the bladder may become hyperreflexic. The parasympathetic preganglionic nerves arise in humans from the S2-S4 spinal cord segments.<sup>[24]</sup> Most preganglionic sympathetic neurons arise from T10-L2 and provide an excitatory input to the bladder neck and urethra to maintain closure of the outlet. The somatic motor supply to the striated muscles of the pelvic floor and intrinsic external urethral sphincter originates from S2-S4 (pudendal nerve). Theoretically, lesions of the vertebrae above T10 should give a hyperreflexic activity in bladder; those below L2 should provoke areflexia. Patients having lesion between D10 and L2, which is sympathetic innervation in bladder sphincter (internal urethral) may cause sphincter disturbances also. In the present study, nearly three-fourth of the patients [40/56 (71.4%)] with spinal lesion above D10 had NDO with or without concurrent DSD and 13 patients had underactive detrusor. Seventeen patients had lesions between D10 and L2 (involving sympathetic pathway). Out of these, only half (9/17) had NDO, whereas others had underactive detrusor. Our findings are similar to that of an earlier study by Wyndaeles where the author had also observed similar pattern, with patients having lesion above D10 showing predominantly NDO and patients having lesion between D10 and L2 showing a mixed pattern.<sup>[13]</sup> These findings highlight the fact the clinical neurological examination alone is not sufficient to predict bladder behavior accurately following myelopathies and bladder management should be based on UDS findings.

Six patients (7.5%) in the study had cauda equina lesion. UDS showed underactive/areflexic detrusor in five out of six patients. One patient had NDO, supporting the view that an overactive bladder may also be found in the absence of an upper motor neuron lesion, a consequence of decentralization of the parasympathetic ganglia situated within the bladder wall<sup>[25,26]</sup> or irritation of the lower sacral roots (as a "positive symptom" of the nerve lesion).

No significant correlation was observed between gender and detrusor behavior ( $P > 0.05$ ). Sixty percent females and 65.9% males in the study had NDO with or without concurrent DSD and the remaining had underactive/normal detrusor pressure.

Significant functional recovery was observed in patients in the study using BI scores ( $P < 0.001$ ). Comparing the mean discharge and admission scores, patients showed significant

improvement in abilities at the time of discharge as compared to admission, irrespective of etiology, severity, and the level of spinal lesion. Similarly, patients showed significant neurological recovery with inpatient rehabilitation using AIS when admission and discharge scores were compared ( $P < 0.001$ ), underlining the importance of rehabilitation for recovery. Inpatient rehabilitation with multidisciplinary approach provides ideal atmosphere, preventive care to avoid secondary complications, and cost-effectiveness of treatment for optimal recovery of the patient as has been shown by some earlier studies.<sup>[20,27]</sup>

### Limitations of the study

Detrusor behavior is dynamic following myelopathies and tends to change with recovery/time, so a longitudinal study would have been more informative to observe such changes and management bladder accordingly. A follow-up study would also have given more insight about the lower and upper urinary tract complications seen in NTM patients with neurogenic bladder.

### Conclusions

Neurogenic bladder was present in all NTM patients in the present study. Paraplegia was more common as compared to quadriplegia, with more incomplete myelopathies suggesting less severe lesions. UDS suggested predominantly NDO with lesions above D10 and mixed pattern with lesions between D10 and L2. No significant correlation was found between detrusor behavior and the level of spinal lesion. Similarly, no significant correlation between detrusor behavior and the severity of NTM and gender was observed. Significant functional and neurological recovery was observed with inpatient rehabilitation.

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