Research Article

Change in urodynamic pattern and incidence of urinary tract infection in patients with traumatic spinal cord injury practicing clean self-intermittent catheterization

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Objective: To observe changes in cystometric parameters in individuals with spinal cord injury (SCI) with neurogenic bladder practicing clean intermittent self-catheterization (CIC) and incidence of urinary tract infection (UTI) in such patients.

Design: Prospective, observational study.

Setting: Tertiary Urban Rehabilitation Hospital.

Participants: Persons with neurogenic bladder caused by traumatic SCI and practicing CIC.

Interventions: Clinical evaluation, complete urine analysis, urine culture and sensitivity, ultrasonography of the abdomen and urodynamic study were evaluated at baseline and at follow-up (6 months to 1 year).

Outcome Measures: Detrusor pattern, cystometric capacity, detrusor compliance, detrusor leak point pressure, residual urine, incidence of UTI.

Results: Thirty-one participants were included in the study. The baseline cystometric study showed that 15 had overactive detrusor and 16 had detrusor areflexia. The mean cystometric capacity decreased significantly between baseline and follow-up in both the groups but remained within the normal threshold limit, decline being more marked in the overactive detrusor group, who also had more marked decrease in compliance. Mean detrusor leak point pressure was below 40 cm H₂O in all participants in both groups at baseline and follow-up. Mean residual urine improved at follow-up in both groups. Incidence of UTI was 2.29 episodes per patient per year, and more frequent in the overactive detrusor group. *Escherichia coli* was the causative agent in 45%.

Conclusion: The cystometric capacity and compliance decreased significantly though patients were doing regular CIC and managed on antimuscarinics for detrusor overactivity (DO). UTI is more common in individuals with SCI with DO and *E. coli* is the most common cause of UTI.

Keywords: Spinal cord trauma, Neurogenic bladder, Intermittent urethral catheterization, Urodynamics, Urinary tract infection

Introduction

Spinal cord injuries (SCIs) are known to cause neurogenic bladder dysfunction¹ which may sometimes result in life-threatening complications. The common urologic problems of neurogenic bladder include an

inability to empty the bladder, urinary tract infection (UTI), incontinence, and upper tract deterioration.^{2,3}

Urodynamic studies are considered the “gold standard” for evaluating bladder and sphincter function and are also useful to document the outcome of treatment.⁴ They are essential because clinical evaluation alone may not be sufficient to initiate effective management.⁵ Optimal bladder management aims to prevent complications and maintain a continent low-pressure bladder by regular complete emptying.³ The introduction of clean intermittent self-catheterization (CIC) by

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Lapides *et al.* in 1972⁶ revolutionized the management of neurogenic bladder, and it is the preferred method nowadays.⁷

UTI is one of the leading causes of morbidity in individuals with SCI.⁸ Several factors appear to be responsible for an increased risk of infection in the neurogenic bladder such as bladder ischemia from overdistension, elevated intravesical pressure, poor bladder compliance, impaired bacterial washout from incomplete emptying, and use of urinary drainage catheters.^{9,10} UTI may interfere with rehabilitation and lead to secondary urologic complications.¹¹

This study was conducted with the aim to observe urodynamic patterns in individuals with traumatic SCI practicing CIC for neurogenic bladder management and the incidences of UTI in such individuals.

Methods

This prospective observational study was conducted at XX from October 2011 to September 2013 after approval by the institute ethics committee. Subjects aged 18–60 years with traumatic SCI (1 year or less) practicing CIC were included in the study. Patients were enrolled in the study after informed consent. The exclusion criteria were co-morbid conditions affecting bladder or renal function.

A detailed history of all the participants was recorded, followed by a complete general physical and neurological examination. Investigations performed included hemogram with erythrocyte sedimentation rate, renal function test, complete urine analysis, urine culture and sensitivity, ultrasonography of the abdomen and urodynamic study at baseline and follow-up (6 months to 1 year). Patients and their attendant were further instructed to repeat the urinalysis and culture on clinical suspicion of UTI after consultation with a local general practitioner. Nelaton catheters (uncoated polyvinyl chloride catheter) were used in this study, which were cleaned with soap and running water, stored in a clean dry cotton (gauze) bag after every use and changed every two weeks. For introduction of the catheter, 2% xylocaine gel was used as the lubricant.

UTI was defined as a colony count of 10^5 colony-forming units per milliliter or greater with fever $>38^\circ\text{C}$ and two symptoms, including bladder overdistention, lower abdominal pain, increased urinary incontinence, increased spasticity, autonomic dysreflexia, and/or increased sweating and malaise. Bacteriuria was defined as a colony count of 10^5 colony-forming units per milliliter or greater, without fever or other symptoms.¹² Patients diagnosed with an acute urinary infection were prescribed antibiotics based on the culture

data and sensitivity testing. Standard laboratory methods were used for the quantitative urine culture and the isolation and identification of organisms. Mean UTI incidence was calculated as the number of UTI incidents/duration of observation (months).

Urodynamic evaluation

Urodynamic study was performed while taking appropriate antibiotics based on the culture and sensitivity. The study comprised of filling and voiding cystometry, using Medtronic Duet Logic G/2 system (Denmark) according to the recommendations of International Continence Society.¹³ Patients were laid supine on a urological table. Following full evacuation of the bladder, cystometry was performed using 8 F double-lumen transurethral urodynamic catheter and a rectal balloon catheter. Room temperature saline was used to infuse the bladder at a slow rate (10 ml/min).

Patients were instructed about the bladder-filling sensations, namely the first sensation of bladder filling, the first desire to void and the strong desire to void and asked to report these sensations. The end point of the filling phase study was strong urge to void as reported by the patient, marked leakage, intravesical pressure exceeding 40 cm H₂O, or signs of autonomic dysreflexia. The urodynamic variables assessed included different bladder-filling sensations, cystometric capacity, compliance, detrusor leak point pressure (DLPP), and residual urine volume.

Detrusor overactivity (DO) is a urodynamic observation characterized by involuntary detrusor contractions during the filling phase which may be spontaneous or provoked.¹⁴ Detrusor areflexia (DA) is defined as acontractility due to an abnormality of nervous control, where the bladder cannot be demonstrated to contract during urodynamic studies.¹⁵ In our study, the patients were divided into two functional urodynamic groups, patients with DO were classified as “overactive detrusor” and patients with DA were classified as “DA”. Those with DO were managed with antimuscarinics (oxybutynin 5 mg TID).

Bladder sensation was classified as “absent”, “preserved” (same as before SCI) or “partially preserved” (different in the quality or magnitude).¹⁶ Bladder compliance was defined as the ratio of a change in bladder volume to the associated change in the intravesical pressure. Compliance ≥ 20 ml/cmH₂O was accepted as normo-compliance and <20 ml/cmH₂O as hypo-compliance.¹⁷ DLPP is defined as the lowest detrusor pressure at which urine leakage occurs in the absence of either a detrusor contraction or increased abdominal pressure. A value of 40 cm H₂O was taken as a cut-off

value to demarcate the intravesical low pressure (<40) and high pressure (≥ 40).¹⁸

Statistical analysis

STATA 14.0 statistical software was used for data analysis. Data are expressed in mean $\pm$ SD for quantitative measurement while number and percentage for qualitative data. Paired *t*-test was applied for the observation of correlated data and $P < .05$ was considered statistically significant.

Observation and results

A total of 33 patients participated in the study and 2 were lost to follow-up.

The demographic profile of the participants is shown in Table 1.

Cystometric observations

The detrusor pattern as observed in cystometry is shown in Table 2.

In the patients with overactive detrusor and DA, a majority of them had either absent or impaired sensation of filling at baseline and follow-up as shown in Table 3.

Table 1 Demographic profile of participants.

Age (mean $\pm$ SD)	28.6 $\pm$ 9.2 years
Duration of injury (mean $\pm$ SD)	3.6 $\pm$ 1.5 months
Duration of follow-up (mean $\pm$ SD)	11.4 $\pm$ 2.4 months
Sex, n (%)	
Male	29 (93%)
Female	2 (7%)
Etiology, n (%)	
Motor vehicle accidents	17 (54.8%)
Fall from height	13 (41.9%)
Others (bullet injury)	1 (3.2%)
Level (NLI)	
Thoracic	20 (64.5%)
Lumbar	11 (35.5%)
AIS, n (%)	
A	19 (61.3%)
B	12 (38.7%)

NLI, neurological level of injury; AIS, American Spinal Injury Association Impairment Scale.

Table 2 Cystometric pattern.

NLI	Detrusor pattern			
	Overactive detrusor (n = 15)		DA (n = 16)	
	Baseline	Follow-up	Baseline	Follow-up
Thoracic (D4-D12)	11	10	9	6
Lumbar (L1-L3)	4	5	7	10

NLI, neurological level of injury.

The cystometric capacity, compliance, and DLPP are shown in Table 4.

At baseline, the cystometric capacity in patients with overactive detrusor was small (<300 ml) in 1 and normal (>300 ml) in 14 and at follow-up, this was 4 and 11, respectively. However, it was normal in all (16) patients with DA both at baseline and follow-up. In patients with an overactive detrusor, compliance was normal (>20 ml/cm of H₂O) in 9 patients at baseline and 4 patients at follow-up. In patients with DA, compliance was normal in 13 patients at baseline and 9 patients at follow-up. A significant decrease in the cystometric capacity and compliance and significant increase in DLPP were observed in both the groups between baseline and follow-up.

Cystometric findings during voiding are as shown in Table 5.

Residual urine volume was more than 150 ml in all patients with DA, both at baseline and follow-up and in most of the patients with an overactive detrusor, 14 at baseline and 11 at follow-up.

The overall incidence of symptomatic UTI was calculated as episodes of urinary infection per 100 patients per day and episodes per patient per year.

A total of 60 episodes of UTI were reported. Most of these, 42 episodes (70%), were seen in patients with overactive detrusor. Mean UTI incidence = number of UTI incidents/duration of observation (months) = 60/313 = 0.191 episodes/patient/month which is 0.636 episodes/100 patient/day or 2.29 episodes/patient/year. *Escherichia coli* was the predominant isolate in 27 cultures (45%), followed by *Klebsiella* in 7 (11.67%), *Proteus* sp., *Pseudomonas* and *Staphylococcus aureus* in 5 cultures each (8.34%), *Acinetobacter*, *Enterococci*, Mixed infection in three cultures each (5%) and *Streptococci* sp. in 2 (3.34%).

Discussion

Most of the patients (93%) in our study were young males with a mean age of 28.6 $\pm$ 9.2 years. Males are more prone for SCI as compared to females consistent with previous epidemiologic studies of SCI in India.¹⁹

Table 3 Cystometric findings: filling phase (sensation).

Bladder sensation	Overactive detrusor n = 15		DA n = 16	
	Baseline	Follow-up	Baseline	Follow-up
Preserved	1	2	0	0
Partially preserved	3	5	8	12
Absent	11	8	8	4

Table 4 Cystometric findings: Filling phase.

Parameter	Overactive detrusor <i>n</i> = 15			DA <i>n</i> = 16		
	Baseline	Follow-up	P value	Baseline	Follow-up	P value
Cystometric capacity (ml)	346 ± 57.5	303.3 ± 33	.007*	465.6 ± 32.8	448 ± 31	.03*
Compliance (ml/cm H ₂ O)	21.8 ± 9.9	16.1 ± 5.9	.001*	30.7 ± 17.0	21.6 ± 6.2	.02*
DLPP (cm H ₂ O)	23.5 ± 7.8	28.0 ± 8.0	.045*	17.2 ± 6.3	22.2 ± 5.2	.001*

All values are shown as mean ± SD; statistical test: paired *t*-test.

*Significant.

Table 5 Cystometric findings: Voiding phase (residual urine volume).

Overactive detrusor <i>n</i> = 15			DA <i>n</i> = 16		
Baseline	Follow-up	P value	Baseline	Follow-up	P value
302.6 ± 71.6	227.6 ± 78.8	.006*	425.2 ± 71.7	394.6 ± 78.8	.005*

All values are shown as mean ± SD; statistical test: paired *t*-test.

*Significant.

In our study, road traffic accident (54.8%) was the major cause of SCI followed by fall from height (41.9%). All the patients were admitted within a year of SCI, and mean duration of injury at time of admission was 3.6 ± 1.5 months. Follow-up was done at re-admission between 6 months to 1 year post discharge; with a mean of 11.4 ± 2.4 months. The neurological level of injury was thoracolumbar spinal cord in all cases, and most common level was T12 and L1 (45%). At the first admission, 61.3% patients had a complete injury (AIS A) and 38.7% were having incomplete injury (AIS B). In all our patients, renal function was within normal limits at baseline and follow-up which indicates that there was no deterioration of renal function in any patient during the observation period. In our study, the baseline cystometric study showed 15 (48.4%) had overactive detrusor and 16 (51.6%) had DA at baseline and on follow-up the type of detrusor pattern remained same in all participants, though neurological level of injury improved. We cannot comment on detrusor sphincter dyssynergia because electromyography was not included in our urodynamic studies. The aim of this study was to prospectively evaluate urodynamic changes in individuals with SCI practicing CIC so that we may be prepared for the long-term complications in spite of CIC and also to observe/compare prospectively the urodynamic bladder profile of two sub-groups, namely the overactive detrusor group and the DA group. Prospective urodynamic evaluation studies and the profile of microbes causing UTI in individuals with traumatic SCI in the Indian context is highly under-reported.

Preservation of bladder sensation, *i.e.* desire to void, is important for sensation-driven bladder emptying in individuals with traumatic SCI as this may aid timely catheterizations and avoid overdistension episodes.¹⁶ Patients with DA had better perception of sensation in cystometric filling phase when compared to the overactive detrusor group. Improvement in sensation was seen at follow-up both in patients with overactive detrusor (3 out of 15) and with DA (4 out of 16).

In our study, the mean cystometric capacity remained within the normal threshold limit in both groups at baseline and follow-up. However, it decreases significantly in both the groups between baseline and follow-up, with the decline being more marked in the overactive detrusor group. Long-term follow-up studies may be required to show if the decrement continues or plateaus and measures to check this decline may need to be incorporated when managing individuals with SCI with low cystometric capacity. In the overactive detrusor group, the mean compliance was normal at baseline which however went below the normal at follow-up. In the DA group, the mean compliance was normal at baseline which decreased on follow-up but remained within normal limits. Bladder compliance decreased in patients regardless of the level or completeness of SCI, or bladder management type, possibly due to chronicity and the effects of neurological change with time as observed in other studies as well.²⁰ As expected, decrease in the cystometric capacity and compliance was more marked in patients with overactive detrusor in relation to those with DA (Table 4) possibly due to mechanical changes in the detrusor muscle including

contracture, change in muscle fiber properties, and loss of viscoelasticity of the detrusor due to post void residuals.²¹

Elevated intravesical pressure is an important risk factor for renal damage in individuals with SCI. McGuire *et al.* in their study proposed 40 cm H₂O as a cut-off value between intravesical low pressure and high pressure.¹⁸ Mean DLPP was below 40 cm H₂O in all participants in both groups at baseline and follow-up, and only one patient developed filling detrusor pressure >40 cm H₂O at follow-up in the overactive detrusor group. High DLPPs are known to correlate with low bladder compliance.²⁰ Mean residual volume improved at follow-up in both groups (Table 5) as some participants were able to generate normal voiding pressure and few developed reflex voiding.

UTI was the most frequent complication of intermittent catheterization observed in our study and as reported in the literature.²² Incomplete voiding, elevated intravesical pressure, and catheter use are reported to contribute to an increased risk of symptomatic UTI and are a major cause of morbidity in SCI cases.²³ In our study, mean UTI episode was 0.19 episodes/patient/month or 2.29 episodes per patient per year. The results are comparable with the results reported by Singh *et al.*² and Esclarín De Ruz *et al.*¹² In our study, out of 60 episodes 42 (70%) occurred in the overactive detrusor group while 18 (30%) episodes occurred in the DA group. Patients with neurogenic DO are more likely to cause high vesicle pressure and, are associated with high incidence of UTI¹² as reflected in our study also. In our study, *E. coli* was the most common offending organism (45%) followed by Klebsella (11.67%). Similar results were reported by Dinh *et al.*²⁴ and Ploypetch *et al.*²⁵ In all our patients, renal function was within normal limits at baseline and follow-up which indicates that there was no deterioration of renal function in any patient during the observation period. In ultrasound abdomen, none of the patient had shown any reduction in renal size, formation of renal calculus, or upper urinary tract dilatation. However, one patient developed vesicle calculi on follow-up ultrasound.

Conclusion

The cystometric capacity and compliance decreased significantly and DLPP increased significantly over time though patients were doing regular CIC and managed on antimuscarinics for DO. UTI is more common in individuals with SCI with DO and *E. coli* is the most common cause of UTI in this population.

Disclaimer statements

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Declaration of interest None.

Conflicts of interest Authors have no conflict of interests to declare.

Ethics approval This study was approved by the Institute Ethics Committee, XX.

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