International Journal of Research in Medical Sciences
Gaikar RR et al. Int J Res Med Sci. 2020 Apr;8(4):1320-1325
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20201317

Original Research Article

Comparison of urodynamic parameters with respect to neurological levels in post-traumatic spinal cord injury patients

Rohit Ramesh Gaikar[1]*, Anil Kumar Gaur[1], Sumedh Narayan More[1], Vaibhav Shivram Lokhande[2], Amol Babanrao Khade[3]

[1]Department of Physical Medicine and Rehabilitation, All India Institute of Physical Medicine and Rehabilitation, Mumbai, Maharashtra, India
[2]Department of Physical Medicine and Rehabilitation, Sakara World Hospital, Bengaluru, India
[3]Department of Physical Medicine and Rehabilitation, Lakhiram Agarwal Memorial, Government Medical College, Raigarh, Chhattisgarh, India

Received: 22 January 2020
Revised: 05 February 2020
Accepted: 28 February 2020

***Correspondence:**
Dr. Rohit Ramesh Gaikar,
E-mail: rohit190485@gmail.com

ABSTRACT

Background: Urodynamic evaluation is mandatory in order to correctly assess and classify bladder dysfunction in spinal cord injury (SCI) patients. Study investigated patterns of neurogenic bladder dysfunction in patients with post traumatic spinal cord injury and assessed the relationship of detrusor leak point pressure with compliance, post void residual urine volume and maximum cystometric capacity.
Methods: Eighty six patients with neurogenic bladder secondary to traumatic spinal cord injury (SCI) underwent cystometry with electromyography (EMG). T-test was used to compare detrusor leak point pressure (LPP) between complete and incomplete injury groups. Pearson correlation test was used to seek correlation between detrusor LPP and compliance, post void residual volume (PRV) and maximum cystometric capacity (MCC).
Results: Mean detrusor LPP in suprasacral complete injury group, suprasacral incomplete injury group and sacral complete injury was 52±21 cm of H_2O, 53±18 cm of H_2O and 16±9 cm of H_2O respectively. No significant difference in detrusor LPP was found between suprasacral complete and incomplete group on t-Test (p= 0.571068). Significant difference in detrusor LPP was found between suprasacral and sacral group (p= 5.71891E-12). Mean compliance in sacral injury group was 24±16 and in suprasacral complete injury group was 5±6. Mean compliance in suprasacral incomplete injury group was 4±2. Pearson correlation showed negative correlation (r = -0.6918934) between detrusor leak point pressure and compliance (p= 1.2744E-13). Negative correlation (r = -0.311409922) was observed between detrusor leak point pressure and post leak/ void residual urine volume (p= 0.003335033) and between detrusor LPP and maximum cystometric capacity (r = -0.31354), (p= 0.003115).
Conclusions: Significant difference in urodynamic parameters exists between sacral and suprasacral injury patients. However there is no significant difference in urodynamic parameters between complete and incomplete injury at suprasacral level.

Keywords: Detrusor hyperreflexia, Detrusor sphincter dyssynergia, Urodynamics

INTRODUCTION

Spinal cord injury is a devastating event that leads to loss of mobility and dependence in most activities of daily life. But what brings most discomfort to the patient is the

risk of urinary and/or fecal incontinence.[1] Management of issue related to an incontinent bladder requires proper assessment and treatment according to the type of lower urinary tract dysfunction. The incidence of deaths due to renal failure or urosepsis after SCI has greatly reduced from 75% in 1969 to 2.3% in 1993.[2,3] In spite of this enormous improvement, it should be noted that the standardized mortality ratio due to urinary system diseases is still 22.8 in SCI patients and even more (172.3) due to septicemia, mainly secondary to urinary tract-related infections.[4] Evidence from current literature dictates that good knowledge of lower urinary tract dysfunction (LUTD) in SCI is essential for physicians involved in rehabilitation of post SCI survivors. It should not be forgotten that neurologic bladder control is an important determinant in quality of life after SCI, and that better control of urinary symptoms, mainly incontinence, can improve it significantly.[5]

The range of bladder symptoms caused by neurologic lesions is wide and determined by whether the lesion primarily affects the supraspinal control, the pontine–sacral neural circuit, or the sacral nerves. Clinically it is expected that, lesions above the brain stem will produce neurogenic detrusor activity (NDO) but no detrusor sphincter dyssynergia (DSD). Suprasacral spinal cord lesions are expected to produce NDO with DSD and sacral lesions are expected to show acontractile detrusor with a weak sphincter.[6] However completeness or incompleteness of the lesion and the possible association of multiple level injuries can complicate this picture, so much so that urodynamic evaluation becomes mandatory in order to correctly assess and classify LUTD in SCI patients.[7]

The EAU (European association of urology) guidelines consider video urodynamics (VUDS) as the gold standard for invasive UDS in patients with neurogenic lower urinary tract dysfunction (NLUTD). Urodynamic studies in general assess the function of the bladder and its outlet during the filling/storage and emptying phases of the micturition cycle.[8]

The diagnosis of DSD is made by urodynamic testing, characterized by the presence of elevated electromyographic activity of external urethral sphincter during detrusor contraction.[9,10] Weld and Dmochowski have reported strong correlation between clinical neurologic findings and urodynamic pattern in SCI patients.[11] Patki et al, have reported salient deterioration in bladder dysfunction in 43 patients with incomplete SCI, despite having relatively near total neurological recovery.[12]

In this study patterns of neurogenic ballder sysfunction were investigated in patients with post traumatic spinal cord injury. The relationships between detrusor leak point pressure and compliance, post void residual urine volume and maximum cystomeyric capacity were also assessed.

METHODS

The study was done to investigate patterns of neurogenic bladder dysfunction in patients with post traumatic spinal cord injury and to assess the relationships between detrusor leak point pressure and compliance, post void residual urine volume and maximum cystometric capacity.

Inclusion criteria

- Diagnosed case of post traumatic spinal cord injury with or without neurological recovery
- Disease duration of > 3 months, or
- Patients recovered from spinal shock phase
- Willing to undergo urodynamic evaluation and pre-urodynamic screening investigations

Exclusion criteria

- Active urinary tract infections
- Bladder calculi
- Bladder cysts or fistula
- Urethral strictures, fistula, false passage

Methodology

A cross sectional observational study was carried out at Department of Physical Medicine and Rehabilitation, All India Institute of Physical Medicine and Rehabilitation, Mumbai over a period of two years from April 2012 to April 2014. Patients suffering from neurogenic bladder secondary to traumatic spinal cord injury, coming to our institute from all over India were included in the study.

Patients who visited the outpatient department or admitted for long term inpatient rehabilitation were counselled and written informed consent was taken prior to urodynamic study, before enrolment in study group. We recorded detailed history of patient's current illness with emphasis on history pertaining to bladder and bowel habits. Thorough neurological examination of each patient was performed and classified according to American Spinal Injury Association (ASIA) impairment scale (© 2020 American Spinal Injury Association).[13] The patients were categorized into neuroanatomical groups according to the neurological level and completeness of injury.

All patients recruited in the study underwent urine routine, microscopy and culture tests. Patients tested positive on culture were treated and taken up for examination only when culture report was negative.

Urodynamic evaluation was performed in all patients using UROCOMP 2000 from Status Medical Equipment, India within 2 year period. The urodynamic evaluation included cystometrogram (filling and voiding cystometry) and surface EMG.

Procedure

After obtaining a written informed consent the patients were explained about the procedure they were about to undergo. Each subject was given proctoclysis enema to ensure that rectum remained empty during study. As an alternative to the triple lumen catheter, 2 infant feeding tubes (size FG 8) were inserted per urethra. One tube was connected to the pressure sensor that measured vesical pressure and the other tube was connected to tubing used to instil normal saline into the bladder.

A rectal balloon was made using a cut off finger from a latex glove tied over the tip of another (size FG8) infant feeding tube. After inserting the rectal balloon into rectum, the tube was connected to the pressure sensor that measured abdominal pressure. The software calculated detrusor pressure by subtracting abdominal pressure from vesical pressure value. A flow rate of 30 ml/min was used with normal saline warmed to patient's body temperature as per international continence society guidelines.[14,15] Through multichannel pressure transduction, intravesical and intra-abdominal pressures were simultaneously recorded and plotted on computer screen along with the sphincter EMG. Sphincter EMG was performed using patch electrodes.

Statistics

Following parameters were taken into consideration

- Detrusor LPP
- Compliance
- PRV
- MCC

T-test was used for comparison of detrusor LPP between complete and incomplete (suprasacral) injury groups. T-test was also used for comparison detrusor LPP between suprasacral and sacral injury groups. Pearson correlation test was used to analyze relationship between detrusor LPP and other parameters (i.e. compliance, PRV and MCC).

RESULTS

A total of 86 patients were evaluated out of which 72 (83.72%) were males and 14 (16.27%) were females. Mean age was 31.86 years. Out of 86 patients 58 (67.44%) had complete injuries and 28 (32.55%) had incomplete injuries as per ASIA criteria.

Thoracic injuries were most common with total 47 (54.65%) patients, followed by 18 (20.93%) lumbar, 12 (13.95%) sacral and 9 (10.46%) cervical level injuries. Level wise distribution of complete and incomplete injuries is given in Table 1. Of the 74 patients with suprasacral lesions, 47 (63.5%) had complete injuries and 27 (36.5%) had incomplete injuries. Detrusor hyperreflexia was observed in 44 (59.5%) individuals with suprasacral complete lesions and 23 (31.1%) suprasacral incomplete lesions.

Table 1: Distribution of complete and incomplete injuries.

Level	Complete	Incomplete
Cervical	5	4
Thoracic	32	15
Lumbar	10	8
Sacral	11	1
Total	58	28

Areflexic detrusor was observed in 6 (8.1%) suprasacral complete and 1 (1.3%) suprasacral incomplete lesions. Detrusor sphincter dyssynergia was seen in 41 (55.4%) suprasacral complete and 22 (29.72%) suprasacral incomplete lesions. In comparison, all 12 patients with sacral injuries (both complete and incomplete) showed detrusor areflexia and none showed detrusor sphincter dyssynergia (Table 2).

Table 2: Pattern of bladder dysfunction in suprasacral and sacral lesions.

Injury	Detrusor hyperreflexia	Detrusor areflexia	DSD
Suprasacral complete	44	6	41
Sacral complete	0	11	0
Suprasacral incomplete	23	1	22
Sacral incomplete	0	1	0
Total	67	19	63

Among the cervical level injury all 9 patients had overactive detrusor and detrusor sphincter dyssynergia. Forty five (95.7%) individuals with thoracic level injuries had overactive detrusor with 2 (4.3%) exhibiting an underactive detrusor pattern. A total of 42 (89.4%) patients with thoracic level injuries displayed detrusor sphincter dyssynergia. All 12 individuals with sacral injuries showed detrusor areflexia and none exhibited detrusor sphincter dyssynergia. Among the patients with lumbar level injuries 13 (72.2%) had overactive detrusor while 5 (27.8%) exhibited detrusor areflexia and 12 individuals had detrusor sphincter dyssynergia. Figure 1 depicts correlation between neurological levels and pattern of urodynamic findings.

As depicted in Table 3, all cervical level injury patients had low compliance (<20) and 8 (88.9%) out of 9 had high (>40 cm of H_2O) detrusor leak point pressure (det. LPP). While 46 (97.9%) out of 47 thoracic level injury patients had low compliance, only 1 (2.1%) showed high compliance (>20). High detrusor LPP was noted in 36 (76.6%) patients with thoracic injuries.

Among the lumbar level injury patients 17 (94.4%) out of 18 had low compliance, while only 1 (5.6%) showed high compliance. High detrusor leak point pressure was noted in 10 (55.6%) patients with lumbar level injuries. Out of 12 sacral level injury patients 6 (50%) exhibited high compliance, but all had low detrusor LPP. Mean detrusor LPP in Suprasacral complete injury group was 52±21 cm of H2O and in suprasacral incomplete injury group was 53±18 cm of H_2O. Mean detrusor LPP in sacral complete injury group was 16±9 cm of H2O. No significant difference in detrusor LPP was found between suprasacral complete and incomplete group on t-test (p = 0.571068). Significant difference was found in detrusor LPP between suprasacral and sacral group (p = 5.71891E-12). Mean compliance in sacral injury group was 24±16 and in suprasacral complete injury group was 5±6. Mean compliance in suprasacral incomplete injury group was 4±2.

Table 3: Correlation between level of injury, detrusor LPP and compliance.

Level of injury	Detrusor lpp ≥40 cm of H_2O	Detrusor lpp <40 cm of H_2O	Compliance ≥20	Compliance <20
Cervical	8	1	0	9
Thoracic	36	11	1	46
Lumbar	10	8	1	17
Sacral	0	12	6	6
Total	54	32	8	78

Statistical analysis using Pearson correlation showed negative correlation (r = -0.6918934) between detrusor leak point pressure and compliance (P = 1.2744E-13). Negative correlation (r = -0.311409922) was also observed between detrusor leak point pressure and post leak/ void residual urine volume (p = 0.003335033). Similarly negative correlation (r = -0.31354) was observed between detrusor LPP and maximum cystometric capacity (p = 0.003115).

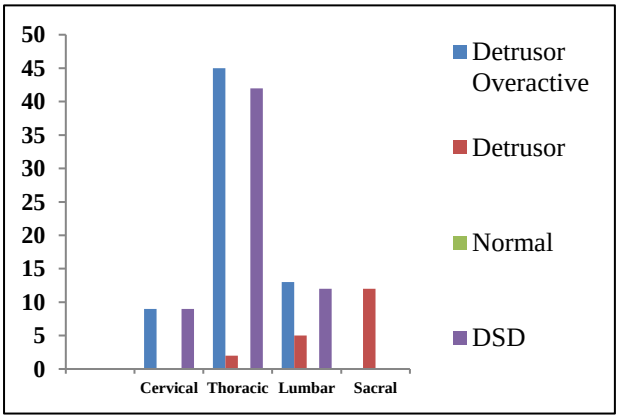

Figure 1: Correlation between neurological levels and urodynamic findings.

DISCUSSION

After the period of spinal shock is over, there is gradual return of reflex bladder function. Conscious sensation of bladder filling may be absent or impaired unless there is neurological recovery. Apart from loss of voluntary inhibition of the micturition reflex, there may be uncontrolled contractions of detrusor muscles (detrusor overactivity) which may or may not be associated with uncoordinated contractions of external sphincter (detrusor sphincter dyssynergia). Typical urodynamic findings in a neurogenic bladder include detrusor overactivity and detrusor striated sphincter dyssynergia (DSD). These uncoordinated contractions result in high voiding pressures, significant residual urine volume, and urinary incontinence which, if not treated, often results in back pressure changes such in upper urinary tract.[1] Though behaviour of detrusor and sphincter is predictable to some extent based on neurological examination, it is not always accurate. In the present study we conducted urodynamic evaluation of 86 post spinal cord injury survivors and classified the findings depending on clinical neurological levels and type of bladder dysfunction.

Numerous studies have attempted to seek correlation between clinical neurologic findings and urodynamic pattern in SCI patients. In our study 90.5% of patients with suprasacral lesions exhibited detrusor hyperreflexia and all patients with sacral lesions displayed areflexia. Similar reports were observed by Weld and Dmochowski, in a population of 243 patients with SCI.[11] Suprasacral lesions were associated with NDO and/or DSD in 94.9%, and sacral lesions with detrusor areflexia in 85.7% of cases. In this study all patients with complete suprasacral injuries had detrusor hyperreflexia and/or detrusor sphincter dyssynergia. Patients with incomplete suprasacral injuries had a slightly lower frequency (93.8%) of hyperreflexia and/or dyssynergia. In our study 85.1% patients with complete suprasacral injury showed detrusor hyperreflexia and 87.2% showed DSD. Among patients with incomplete suprasacral injuries 85.1% had detrusor hyperreflexia and 81.5% had DSD. No significant difference was observed between complete and incomplete suprasacral injury group, which was similar to the study by Weld et al. In a similar study of 489 patients with spinal cord lesions Kaplan et al. found a general correlation between the neurological level of injury and the expected vesicourethral function, but also

noted that it was neither absolute nor specific.[16] They noted that, 84% of the suprasacral cord lesions with detrusor areflexia had positive sacral cord signs while all suprasacral cord lesions with no evidence of sacral cord involvement had either detrusor hyperreflexia or detrusor-external sphincter dyssynergia. Thus implying that clinical assessment for sacral cord signs may help predict bladder behaviour in such cases. They also suggested that the clinical neurological examination alone is not an adequate to predict neurological dysfunction. In another study Bulent et al. reported detrusor hyperreflexia in Twenty-six (72.2%) of 36 patients with suprasacral injuries.[17] Twenty-nine (80.5%) had detrusor sphincter dyssynergia, 9 (25%) had normal compliance and 1 (2.8%) had areflexia. In a recent study by Maryam et al out of 66 patients with suprasacral injuries 27 (40.90%) had detrusor hyperrflexia and 5 (17.9%) out of 19 sacral injuries had detrusor hyperreflexia.[18] These findings differ significantly from observations in the study.

Moslavac et al, in their study of 80 spinal cord injury patients with detrusor hyperreflexia found no difference in cystometric capacity and intravesical leak point pressure between complete and incomplete spinal cord injury patients.[19] Mean CC (cystometric capacity) for ASIA A group was 239±107 ml (range 47 - 526) and mean CC for ASIA B–E group was 227±125 ml (range 42-500). In the study mean MCC (maximum cystometric capacity) for ASIA A group with detrusor hyperreflexia was 190±81 ml and mean MCC for ASIA B-E group with detrusor hyperreflexia was 202±59 ml. Moslavac et al also reported mean Pves leak-point pressure (Pves LPP) at cystometric capacity for ASIA A group as 79±30 cm H2O (range 26-140) and mean Pves LPP for ASIA B-E group as 70±29 cm H_2O (range 25 - 130). In the study, it was found that mean Det. LPP of 57±17 cm of H_2O in ASIA A group (with detrusor hyperreflexia) and 55±18 cm of H_2O in ASIA B-E (with detrusor hyperreflexia).

Weld et al also reported a higher frequency of impaired compliance in sacral injury group (78.6%) compared with the suprasacral injury group (41.8%).[11] They also observed correlation of high detrusor leak point pressures with low bladder compliance. Low compliance was observed in 97.3% of suprasacral injury group and 50% of sacral injury group. However the definition of low compliance in Weld et al was <10, while in present study it is <20; which may explain the observed differences. We found negative correlation of detrusor leak point pressure with compliance, post void residual urine volume and maximum cystometric capacity as has been documented by various studies.

In the study 2 thoracic level and 5 lumbar level lesions with detrusor areflexia was found. Some other authors have also noted occurrence of detrusor areflexia with upper motor neuron lesions, presumably due to a coexistent clinical or subclinical spinal cord lesion. Arnold et al. reported two cases of upper motor neuron lesions with detrusor areflexia.[20] Light et al. also reported 13 patients with suprasacral SCI and detrusor areflexia.[21]

CONCLUSION

Significant difference in urodynamic parameters exists between sacral and suprasacral injury patients. However there is no significant difference in urodynamic parameters between complete and incomplete injury at suprasacral level. Negative correlation exists between detrusor LPP and compliance, PRV and MCC. In most setups without availability of urodynamic study, there is tendency among treating physicians to treat patients based on clinical judgment. As evident from current study, judgments made from the neurologic examination may be incorrect because of the superimposed complexity of multiple injury levels. Urodynamic study in spinal cord injury patients may provide better acumen about bladder pathology which may provide for better bladder management protocol.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Rajendra Sharma, MD, for his guidance. The authors would also like to thank ASIA (American spinal injury association) for permitting use of ASIA scale in this research project.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Rudy DC, Awad SA, Downie JW. External sphincter dyssynergia: an abnormal continence reflex. J Urol. 1988;140(1):105-10.
2. Tribe CR, Silver JR. In: Renal failure in paraplegia. Pitman, London, UK. 1969:54-90.
3. Devivo MJ, Black KJ, Stover SL. Causes of death during the first 12 years after spinal cord injury. Arch Phys Med Rehabil. 1993;74:248-54.
4. Soden R, Walsh J, Middleton J, Craven M, Rutkowski, Susie Y. Causes of death after spinal cord injury. Spinal Cord. 2000;38:604-10.
5. Ku J. The management of neurogenic bladder and quality of life in spinal cord injury. BJU Int. 2006;98:739-45.
6. Schöps TF, Schneider MP, Steffen F, Ineichen BV, Mehnert U, Kessler TM. Neurogenic lower urinary tract dysfunction (NLUTD) in patients with spinal cord injury: long-term urodynamic findings. BJU Int. 2015;115:33-8.
7. Stöhrer M, Bertil CD, David CK, Emmanuel DP, G K, Guus P. EAU guidelines on neurogenic lower urinary tract dysfunction. European Urol. 2009;56:81-8.
8. Groen J, Pannek J, Castro DD, Del PG, Gross T, Hamid R, et al. Summary of European association

of urology (EAU) guidelines on neuro-urology. European Urol. 2016;69(2):324-33.
9. Elise D, Patel C, Tharian B, Westney O, Graves D, Hairston J. Diagnostic discordance of electromyography versus voiding cystourethrogram for detrusor-external sphincter dyssynergy. Neurourol Urodyn. 2005;242:616-21.
10. Sara S, Carmin K, Elise D. Combined diagnostic modalities improve detection of detrusor external sphincter dyssynergia. ISRN Obst Gynecol. 2011;32:3421.
11. Dmochowski K. Association of level of injury and bladder behavior in patients with post-traumatic spinal cord injury. Urol. 2000;55:490-4.
12. Patki P, Woodhouse J, Hamid R. Lower urinary tract dysfunction in ambulatory patients with incomplete spinal cord injury. J Urol. 2006;175:1784-7.
13. American spinal injury association. International standards for neurological classification of SCI (ISNCSCI) worksheet. Available at https:// asia-spinalinjury.org/international-standards-eurological - classification - sci - isncsci-worksheet/. Accessed on 15 December 2019.
14. Schafer W, Abrams P, Liao L, Mattiasson A, Pesce F, Spangberg A, et al. Good urodynamic practices: uroflowmetry, filling cystometry and pressure-flow studies. Neurourol Urodyn. 2002;21:261-74.
15. Gammie A, Clarkson B, Constantinou C, Damaser M, Drinnan M, Geleijnse G, et al. International continence society guidelines on urodynamic equipment performance. Neurourol Urodyn. 2014;33:370-9.
16. Steven K, Michael C, Jerry B. Bladder and sphincter behavior in patients with spinal cord injury. J Urol. 1991;146:113-7.
17. Erol B, Koçak T, Kadıoğlu A, Müslümanoğlu L, Karamehmetoğlu S, Akıncı M, et al. The relationship between level of injury and bladder behaviour in patients with post-traumatic spinal cord injury. Ulus Travma Acil Cerrahi Derg. 2009;15(4):377-82.
18. Kooshesh M, Safdarian M, Nikfallah A, Vaccaro AR, Movaghar RV. Association between detrusor muscle function and level of the spinal cord injury. Cent European J Urol. 2018;71(1):92-7.
19. Sasa M, Dzidic I, Kejla Z. Neurogenic detrusor overactivity: comparison between complete and incomplete spinal cord injury patients. Neurourol Urodynamics. 2008;27:504-6.
20. Arnold EP, Fukui J, Anthony A, Utley WL. Bladder function following spinal cord injury: a urodynamic analysis of the outcome. Br J Urol. 1984;56(2):172-7.
21. Light JK, Faganel J, Beric A. Detrusor areflexia in suprasacral spinal cord injuries. J Urol. 1985;134(2):295-7.

Cite this article as: Gaikar RR, Gaur AK, More SN, Lokhande VS, Khade AB. Comparison of urodynamic parameters with respect to neurological levels in post-traumatic spinal cord injury patients. Int J Res Med Sci 2020;8:1320-5.