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Original Research Article

Clinical significance of gender-specific urodynamic investigation in evaluating bladder functional recovery in patients with lumbar intervertebral disc prolapse

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ABSTRACT

Background: Lumbar intervertebral disc prolapse (LDP) frequently causes neurogenic bladder dysfunction due to sacral root compression. Urodynamic investigation is the gold standard for assessment, but the influence of gender on bladder functional recovery after decompression surgery remains unclear. Objectives were to evaluate the clinical significance of gender-specific urodynamic investigation in assessing bladder functional recovery after lumbar decompression surgery in patients with LDP.
Methods: This prospective longitudinal study included 30 patients (20 males, 10 females) with LDP who underwent microdiscectomy. Urodynamic parameters-maximum cystometric capacity (MCC), post-void residual urine (PVR), maximum detrusor pressure (Pdetmax), bladder compliance (BC), and maximum flow rate (Qmax)-were measured preoperatively and three months postoperatively. Gender-specific changes were analysed using paired t test, Wilcoxon signed-rank test, and McNemar-Bowker test.
Results: Preoperative urodynamic abnormalities were present in 73.3% of patients, with no significant gender differences at baseline. In males, significant improvements were observed in MCC (+14.95 ml, p=0.009), PVR (-16.06 ml, p<0.001), and Qmax (+4.90 ml/s, p<0.001). In females, only PVR showed a significant reduction (-54.86 ml, p=0.001). Overall, urodynamic normalisation occurred in 18.8% of males but in none of the females. Detrusor overactivity resolved in 25% of males versus 0% of females.
Conclusions: Gender significantly influences urodynamic recovery following lumbar decompression for LDP. Males attain more extensive and pronounced improvements, whereas females demonstrate limited recovery. Gender-specific urodynamic assessment is of considerable clinical importance for prognostication and personalized rehabilitation.

Keywords: Lumbar intervertebral disc prolapse, Urodynamic study, Gender difference, Bladder functional recovery, Neurogenic bladder, Decompression surgery

INTRODUCTION

Lumbar intervertebral disc prolapse (LDP) is a prevalent etiological factor for low back pain and radiculopathy, with a peak incidence in the fourth to sixth decades of life.[1,2] Beyond the well-recognized musculoskeletal manifestations, compression of the cauda equina and lumbosacral nerve roots-particularly the sacral

parasympathetic fibers (S2-S4) responsible for detrusor contraction and bladder sensation-frequently precipitates lower urinary tract dysfunction.[3] This encompasses a spectrum of bladder storage and voiding abnormalities, including detrusor overactivity, underactivity, impaired BC, and elevated PVR.[4,5] Progressive neural compression may initially induce irritative symptoms through nerve root stretching, subsequently followed by a loss of bladder sensation, detrusor areflexia, and subsequent voiding difficulty as compression advances.[6] Therefore, lower urinary tract symptoms (LUTS) are highly prevalent among this cohort, with moderate-to-severe manifestations reported in up to 46% of surgical candidates and an overall incidence ranging from 27% to 92%.[7,8] If unrecognized or inadequately managed, neurogenic bladder dysfunction may culminate in upper urinary tract deterioration and end-stage renal disease.[9] Accurate assessment of bladder function in LDP requires urodynamic investigation, providing objective, quantitative metrics of detrusor activity, sphincter coordination, and bladder sensation.[10] Approximately 40% of individuals with lumbar disc pathology exhibit abnormal urodynamic profiles.[11] Common abnormalities include an acontractile or underactive detrusor, indicative of parasympathetic denervation, with less frequent detection of detrusor overactivity during early or irritative stages.[12] Urodynamic studies (UDS) serve a critical prognostic role, especially in cauda equina syndrome (CES), a surgical emergency affecting 0.07% to 2% of LDP cases, where quantitative findings correlate with postoperative restoration of voiding function.[8,13] Nevertheless, existing literature often presents inconsistent evidence regarding bladder recovery. Certain studies report persistent irreversible bladder dysfunction post-surgery, whereas others suggest that favorable functional outcomes are achievable, particularly with prompt intervention, with bladder normalization rates ranging from 40% to 81% following timely decompression.[14,15] Despite these findings, there remains a significant gap in understanding the influence of gender on these outcomes. Emerging evidence from spinal cord injury research indicates notable gender-based differences in neurogenic bladder symptoms and quality of life, with women frequently experiencing more severe symptoms but deriving greater benefits from surgical intervention.[16] Specifically, in cauda equina lesions, female gender has been independently associated with more severe urinary incontinence and defecation dysfunction at presentation.[17] Moreover, female patients with lumbar disc prolapse and an areflexic detrusor, who strain during voiding, are especially susceptible to developing genuine stress incontinence.[18] The impact of gender-specific disparities on urodynamic recovery following decompression surgery remains insufficiently explored, as most prospective studies do not incorporate gender stratification or primary analysis of gender as a variable.[19] This investigation aims to elucidate the clinical significance of gender-specific urodynamic assessment in evaluating bladder recovery in individuals with LDP. By comparing preoperative and postoperative urodynamic parameters between males and females, this study endeavours to clarify gender variations in detrusor recovery, voiding efficiency, and long-term bladder outcomes.

Objectives

General objective

General objectives were to evaluate the clinical significance of gender-specific urodynamic investigation in assessing bladder functional recovery after lumbar decompression surgery in patients with LDP.

Specific objectives

Specific objectives were to compare preoperative urodynamic parameters between male and female patients, to assess gender-specific changes in urodynamic parameters before and three months after surgery. And to determine the influence of gender on the pattern and degree of bladder functional recovery.

METHODS

This prospective longitudinal analytical study was conducted at the Department of Urology, Bangladesh Medical University, Dhaka, in collaboration with the Department of Neurosurgery, from April 2024 to September 2025. The study protocol received ethical approval from the Institutional Review Board of Bangladesh Medical University, and all procedures complied with the Declaration of Helsinki. The study population comprised adult patients of both sexes diagnosed with LDP who underwent lumbar decompression surgery (microdiscectomy). Patients were recruited from the Urology outpatient department and the Neurosurgery inpatient ward. Inclusion criteria were age 18 years or older, radiological confirmation of LDP by magnetic resonance imaging, and willingness to provide written informed consent. Exclusion criteria included previous spinal surgery, active urinary tract infection confirmed by urine culture, diabetes mellitus (to avoid diabetic cystopathy as a confounder), history of lower urinary tract injury or surgery, established paraplegia from any cause, benign prostatic hyperplasia or other causes of bladder outlet obstruction in males, and pregnancy or pelvic organ prolapse in females.

Sample size was calculated based on preoperative and postoperative PVR data from a previous study. The minimum required sample was 35 patients, and after accounting for a 10% anticipated loss to follow-up, 39 patients were enrolled. Purposive sampling was employed, and all eligible patients who provided consent during the study period were consecutively included. Ultimately, 30 patients (20 males and 10 females) completed the study and were available for final analysis. The independent variable was gender (male versus female). The dependent urodynamic variables were MCC

in millilitres, PVR in millilitres, Pdetmax in centimetres of water, BC in millilitres per centimetre of water, and Qmax in millilitres per second.

After obtaining written informed consent, demographic data, medical history, and physical examination findings were recorded for each patient. Preoperative investigations included urinalysis, urine culture and sensitivity, random blood glucose, serum creatinine, ultrasonography of the kidney, ureter, and bladder region, and a complete urodynamic study. All urodynamic investigations were performed by a single experienced urologist, blinded to the final diagnosis, using a computer-assisted urodynamic system (PICO compact-3000 System, Menfis BioMedica, Bologna, Italy), and followed International Continence Society standards. Patients were instructed to discontinue antimuscarinic and alpha-blocker medications 72 hours before the study. On the day of the procedure, free uroflowmetry was recorded with the patient voiding spontaneously on a commode. Under aseptic conditions, a 5-French double-lumen urethral catheter was inserted to measure intravesical pressure, and a rectal balloon catheter was placed 10 cm from the anal margin to measure abdominal pressure. Detrusor pressure was derived electronically by subtracting abdominal pressure from intravesical pressure. The bladder was filled with normal saline at room temperature at a rate of 50 millilitres per minute. During filling, the patient reported first sensation, first desire to void, and strong desire to void. MCC was recorded at the point of strong desire to void or when the examiner stopped infusion due to safety criteria. At maximum filling, the patient was asked to void in the supine position while pressures and flow rate were continuously recorded. BC was calculated as the change in bladder volume divided by the change in detrusor pressure during filling. Pdetmax was the highest-pressure during voiding, and Qmax was the peak urine flow. PVR volume was measured by catheter drainage after voiding. All patients then underwent lumbar microdiscectomy performed by consultant neurosurgeons under general anaesthesia. The same urodynamic protocol was repeated three months after surgery by the same operator using identical equipment.

The primary outcomes were changes in MCC, PVR, Pdetmax, BC, and Qmax from baseline to three months postoperatively, stratified by gender. Secondary outcomes included the proportion of patients who normalised specific urodynamic abnormalities (detrusor overactivity, pathological PVR, reduced Qmax, reduced bladder capacity) and the overall urodynamic normalisation rate, defined as conversion from an abnormal to a normal study. Statistical analysis was performed using SPSS version 26.0. Normality of continuous variables was assessed with the Shapiro-Wilk test. Normally distributed data were expressed as mean ± standard deviation and compared using the paired t test (within-gender pre- versus post-operative) or independent t-test (between genders). Non-normally distributed data were presented as medians with interquartile ranges and compared using the Wilcoxon signed-rank test or the Mann-Whitney U test. Categorical variables were analysed using the McNemar test, McNemar-Bowker test, or Fisher's exact test as appropriate. The geometric mean was used for PVR due to skewed distribution. A two-tailed p-value less than 0.05 was considered statistically significant. Confidentiality of patient data was strictly maintained, all data were anonymised, and participants retained the right to withdraw at any time without affecting their medical care. No financial incentives were provided, and all procedures were part of routine clinical management.

RESULTS

A total of 30 patients with LDP who underwent decompression surgery completed the study. Preoperative urodynamic abnormalities were present in 73.3% of patients. The following results are presented in accordance with the study objectives.

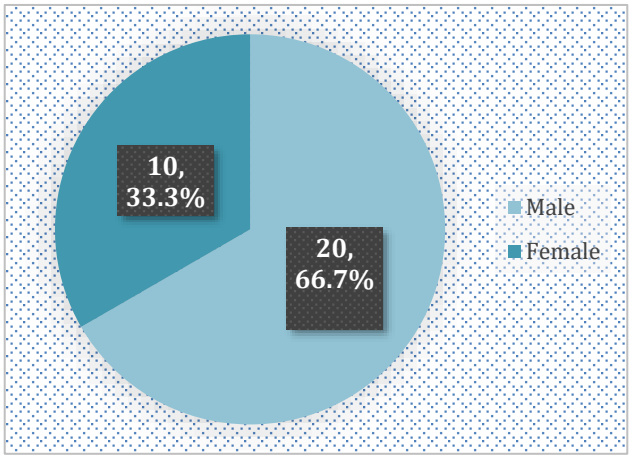

Figure 1: Distribution of gender of patients, (n=30).

Figure 1 shows the distribution of gender in this study. Among 30 patients, males were predominant (20, 66.7%). Male and female ratio was 2:1.

Table 1 abridges preoperative urodynamic parameters by gender. Male patients had higher mean MCC (432.60 ml vs. 406.50 ml) and post-void residual (140.26 ml vs. 85.13 ml) and slightly higher Pdetmax (26.81 vs. 22.95 cm H_2O). BC was similar (median 17.65 ml/cm H_2O in males vs. 17.20 in females). The Qmax was lower in males (12.40 ml/s vs. 18.45 ml/s), but none of these differences were statistically significant (all $p>0.05$), indicating comparable preoperative urodynamic parameters.

Table 2 shows MCC changes before and three months after surgery. In males, MCC increased significantly from 432.60±121.65 ml to 447.55±69.72 ml (mean +14.95 ml, $p=0.009$). Females also showed an increase from 406.50±141.68 ml to 428.20±57.68 ml, with a mean

change of +21.70 ml, but this was not statistically significant (p=0.56). These results suggest males have a modest, significant improvement in bladder capacity after decompression.

Table 3 shows pre- and post-op PVR values. Both genders had significant PVR reduction after surgery. In males, PVR dropped from 140.26 ml to 124.20 ml (-16.06 ml, p<0.001). Females saw a larger decrease from 85.13 ml to 30.27 ml (−54.86 ml, p=0.001). Although females had a bigger reduction, the gender difference in improvement wasn't directly compared. Surgery improved voiding efficiency in both sexes.

Table 4 shows Qmax changes. Male patients improved from 12.40 to 17.30 ml/s (+4.90 ml/s, p<0.001). Females increased from 18.45 to 21.90 ml/s (+3.45 ml/s), but the difference was not significant (p=0.08). Males with lower baseline flow showed greater benefits after decompression.

Table 1: Preoperative urodynamic parameters by gender.

Parameters	Male, (n=20)	Female, (n=10)	P value*
MCC (ml), mean±SD	432.60±121.65	406.50±141.68	0.59
PVR (ml), mean±SD†	140.26±152.99	85.13±193.27	0.32
Pdetmax (cmH₂O), mean ± SD	26.81±11.83	22.95±12.37	0.41
BC (ml/cmH₂O), median (IQR)	17.65 (26.01)	17.20 (15.03)	0.68
Qmax (ml/s), median (IQR)	12.40 (8.0)	18.45 (13.4)	0.09

*Independent t-test or Mann-Whitney U test; †Geometric mean. MCC=maximum cystometric capacity; PVR=post-void residual; Pdetmax=maximum detrusor pressure; BC=bladder compliance; Qmax=maximum flow rate.

Table 2: Changes in MCC by gender.

Gender	Pre-op MCC (ml) mean±SD	Post-op MCC (ml), mean±SD	Mean change (Δ)	P value*
Male	432.60±121.65	447.55±69.72	14.95	0.009
Female	406.50±141.68	428.20±57.68	21.7	0.56

*Paired t-test.

Table 3: Changes in PVR by gender.

Gender	Pre-op PVR (ml)* mean±SD	Post-op PVR (ml)* mean±SD	Mean change (Δ)	P value†
Male	140.26±152.99	124.20±138.66	-16.06	<0.001
Female	85.13±193.27	30.27±136.22	-54.86	0.001

*Geometric mean; †Paired t-test.

Table 4: Changes in Qmax by gender.

Gender	Pre-op Qmax (ml/s) median (IQR)	Post-op Qmax (ml/s) median (IQR)	Median change (Δ)	P value*
Male	12.40 (8.0)	17.30 (8.8)	4.9	<0.001
Female	18.45 (13.4)	21.90 (11.8)	3.45	0.08

*Wilcoxon signed-rank test.

Table 5: Gender influence on recovery of specific urodynamic abnormalities.

Recovery outcome	Male	Female
Detrusor overactivity resolution	3/12 (25.0%)	0/5 (0%)
Pathological PVR normalisation	3/9 (33.3%)	0/3 (0%)
Reduced Qmax normalisation	5/10 (50.0%)	1/4 (25.0%)
Reduced bladder capacity normalisation	4/6 (66.7%)	1/1 (100%)
Overall urodynamic normalisation	3/16 (18.8%)	0/6 (0%)

Table 5 depicts the proportion of patients who normalised specific urodynamic abnormalities after surgery, stratified by gender. For detrusor overactivity, resolution occurred in 3 out of 12 affected males (25.0%) but in none of the 5 affected females (0%). Pathological PVR normalised in 33.3% of males (3/9) compared to 0% of females (0/3). Reduced Qmax was normalised in half of the affected males (5/10, 50.0%) and in one-quarter of affected females (1/4, 25.0%). Notably, reduced bladder capacity normalised in 4 of 6 males (66.7%) and in the single

affected female (100%). Overall, urodynamic normalization (conversion from abnormal to normal) was achieved in 3 of 16 males (18.8%) but in none of the 6 females with preoperative abnormalities (0%). These findings suggest a consistent trend favouring male patients in the resolution of most urodynamic abnormalities, except for bladder capacity normalisation, where the single female case improved.

DISCUSSION

This study examined how gender influences urodynamic changes in patients with LDP before and three months after lumbar decompression surgery. The results showed that male patients experienced significant improvements in several bladder function metrics, whereas female patients showed only a reduction in post-void residual urine. These findings show that gender-specific urodynamic assessments are crucial to accurately predict and monitor bladder recovery after lumbar decompression.

In this study, preoperative urodynamic parameters did not differ significantly between males and females, though males had higher MCC and PVR and lower Qmax. This aligns with previous reports that bladder function in LDP is predominantly determined by the level and degree of neural compression rather than by gender per se.[11,14] However, the trend toward lower Qmax in males may be due to age-related prostate enlargement or longer urethra, which could affect voiding dysfunction interpretation.[5] Despite numerical differences, the lack of significance indicates similar urodynamic impairment before surgery for both genders, making postoperative differences more relevant.

A notable increase in MCC was observed only in male patients (+14.95 ml, p=0.009), whereas females showed a non-significant rise. This aligns partly with Cong et al who found improved bladder capacity after decompression in a mixed-gender group.[14] However, our gender-specific analysis shows that the overall gain was mainly due to males. The larger storage recovery in men might be because male bladders are more responsive to re-innervation after sacral root decompression, potentially due to higher baseline parasympathetic activity or more neural pathway redundancy.[20] Alternatively, the smaller female sample size (n=10) could have limited the ability to detect a significant change in MCC; the mean increase of 21.70 ml is clinically relevant but not statistically significant.

Both genders showed significant reductions in PVR after surgery, confirming that lumbar decompression effectively alleviates outlet obstruction and improves bladder emptying. Females had a larger absolute decrease in PVR (-54.86 ml vs. -16.06 ml in males), likely due to their lower baseline PVR (85.13 ml vs. 140.26 ml), allowing greater proportional improvement. Since females don't have a prostate, they might recover their detrusor contractility more completely after neural compression is relieved. Yamanishi et al also found that women with urinary retention from central disc prolapse often regain full voiding post-surgery.[18] Regarding Qmax, males had a significant increase (12.40 to 17.30 ml/s, p<0.001), but females did not (p=0.08). This aligns with Khursheed et al who reported that decompression normalizes flow in about 50% with preoperative voiding issues.[15] The lack of change in females may be due to their higher baseline Qmax (18.45 ml/s), limiting further gains (ceiling effect). The Wilcoxon test, suitable for non-normal data, may also be less sensitive to small changes in small groups.

Male patients had higher normalization rates of urodynamic issues, except for one female with improved bladder capacity. Detrusor overactivity resolved in 25% of males but not females; this is a new finding, as earlier studies often lack gender-specific data. Females might exhibit lower resolution because of hormonal factors or longer symptom duration.[17,21] Pathological PVR normalized in one-third of males but not females, indicating persistent underactivity despite decompression. Overall, 18.8% of males and 0% of females achieved urodynamic normalization. While low, these rates align with 20-30% in other studies at three months.[14] A longer follow-up might show more improvement, as neural recovery can take up to a year.[13]

Our findings support Hellström et al who reported that only a minority of patients regained normal bladder function after cauda equina syndrome surgery. Recent studies show 40-81% normalisation after timely decompression.[14,15] Discrepancies may be due to differences in surgical timing, severity of disc prolapse, and follow-up. Our study, with gender-specific analysis, shows that previously reported “good” outcomes are mostly from male patients. Korse et al found women presented with worse incontinence, and ours shows they also have poorer urodynamic recovery. Women with LDP and bladder symptoms may need more preoperative counselling and postoperative care compared to men. Although urodynamic investigation is the gold standard for assessing neurogenic bladder,[10] our results indicate that routine application of gender-disaggregated urodynamic analysis provides superior prognostic value. Male patients exhibit measurable gains in MCC, post-void residual volume, and Qmax, with an overall urodynamic normalization rate of 18.8%. Female patients, however, demonstrate improvement limited solely to post-void residual volume; restoration of other parameters typically requires adjunctive interventions, including pelvic floor therapy, anticholinergics, or catheterization following decompressive surgery.[18,22] Thus, adopting gender-specific urodynamic reporting as a standard part of preoperative and postoperative evaluation aligns with the principles of personalized medicine. neurosurgery and neuro-urology.[19]

Limitations

Several limitations exist: a small sample size (30 patients, 10 females), limited follow-up of 3 months, and a lack of assessment of factors such as disc prolapse levels, preoperative symptom duration, and confounders, including benign prostatic hyperplasia or prior pelvic surgery. No postoperative MRI confirmed decompression, and patient outcomes weren't correlated with urodynamic data.

CONCLUSION

Gender significantly influences urodynamic recovery after lumbar decompression surgery for LDP. Male patients show significant improvements in MCC, post-void residual urine, and Qmax, along with higher rates of normalisation of detrusor overactivity and other urodynamic measures. Conversely, female patients exhibit only a modest decrease in post-void residual urine. Therefore, gender-specific urodynamic assessment is valuable for prognosis, preoperative counseling, and personalized postoperative bladder management. Larger, multicenter prospective studies with extended follow-up and radiological and clinical correlations are necessary to confirm these results. Additionally, routine urodynamic reporting should include gender-specific analysis to enhance surgical decision-making and postoperative care for patients with lumbar disc prolapse.

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