

A Prospective Study of Clinicoradiologic-Urodynamic Correlation in Patients with Tuberculosis of the Spine

Abstract

Introduction: Involvement of spinal cord in spinal tuberculosis (TB) has been associated with bladder disturbances on which literature is scarce. The present study aimed at evaluating the urodynamic profile, its correlation with clinical and radiological features, and the prognosis with treatment in these patients. **Materials and Methods:** Thirty patients of spinal TB were prospectively evaluated clinically, radiologically, and urodynamically in this single center prospective study. All patients underwent urodynamic assessment at presentation; and those with bladder dysfunction on initial urodynamics were followed with sequential testing at 3, 6, and 12 months. **Results:** Patients were divided into two groups on the basis of the absence (Group 1, $n = 14$) or presence (Group 2, $n = 16$) of bladder dysfunction. The magnitude of deformity ($P = 0.011$), sensory deficit ($P = 0.025$), and tenderness ($P = 0.030$) at presentation was found to be significantly more in Group 2 and involvement of posterior elements, reduction in disc height, endplate erosion, and nerve root were significantly higher. The initial urodynamic assessment showed delayed sensations in 23.3% and early sensations in 13.3%, respectively; decreased bladder compliance in 3.33%; underactive detrusor in 16.6%, and overactive in 13.3% of cases. The sphincter was dyssynergic in 13.3% of cases. Statistically significant ($P < 0.001$) improvement in sensory parameters of bladder, detrusor contractility, and compliance with treatment was observed. Thirteen (81.3%) patients of Group 2 showed overall improvement on serial urodynamics after chemotherapy. Patients with bladder disturbances had poorer functional recovery at 6 and 12 months. **Conclusion:** Significant bladder comorbidity is associated with spinal TB and its presence can be recognized as a poor prognostic factor. Urological morbidity is strongly linked to the nerve root and posterior element involvement; reduction in disc height; and end plate erosion. Clinical/neurological improvement correlates with marked radiological and urological improvement.

Keywords: Correlation, magnetic resonance imaging, spinal tuberculosis, urodynamic study

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Introduction

Spinal tuberculosis (TB) is one of the most common affections of extrapulmonary TB.¹ The extent and level of involvement of the spinal/vertebral segment decide the clinical neurological impairments. The associated bowel bladder involvement in these patients is quite common which is often overlooked and less attended. The pattern of bladder involvement in correlation with the serial radiological investigations and the treatment of the existing bladder comorbidities along with antitubercular therapy with/without surgery have been scarcely documented.^{2,3} The aim of the present study was to evaluate the bladder profile and correlate the same with clinical, neurological, and radiological findings and its improvement with treatment.

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Materials and Methods

This prospective study was carried at a tertiary care center in thirty patients suffering from spinal TB as evident on clinicoradiologic evaluation. The Institutional Ethics Committee approved the protocol. Informed written consent was obtained from all the patients included in the study.

Patients with any traumatic spinal cord lesion earlier with/without head injury, tumors, medically unstable condition, patients presenting with previous neurological deficits, preexisting bladder comorbidities, seropositive cases (HIV, hepatitis B surface antigen, hepatitis C virus), medical/surgical illness involving bladder disturbances such as diabetes, benign prostatic hyperplasia, cerebrovascular accident, urethral stricture and severely immunocompromised patients

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likely to affect healing and involvement pattern were excluded from the study.

At initial presentation, clinical examination both physical and neurological was performed according to Tuli's,⁴ American spinal injury impairment scale (ASIA),⁵ Jain and Sinha⁶ classification of stages of paraplegia along with basic hematological and radiological investigations. Detail micturition history was taken about storage and voiding problems and all the patients were subjected to urodynamic study (UDS) at initial presentation. Patients were treated with antituberculous treatment (ATT) for 12 months and requisite surgical procedure along with ATT was followed in patients requiring surgery.

Followup was done at 3 months, 6 months, and 12 months. Patients were followed up with routine hematological investigations, radiological investigations in all patients, and UDS at 3 months, 6 months, and 12 months only in patients with bladder dysfunctions.

Urodynamic assessment

All included patients underwent urodynamic testing using the Triton™ Urodynamic system by Laborie®. The patients were given preprocedural instructions, including local shaving, laxatives one night before the test, and enema in the morning. Prophylactic antibiotic in the form of ciprofloxacin was advised to all patients preferably in the morning and at least 2 h before the test. Patients were positioned on a flexible urodynamic chair and parts were cleaned and draped. A double-lumen 8 Fr catheter was placed into the bladder per urethra after instillation of topical anesthetic jelly.

A rectal balloon catheter was then placed per rectum after removing all the air from the balloon and charging the catheter with saline. Surface electrodes were placed in the perineum and perianal region and another surface electrode was placed over a bony prominence as the neutral. The transducer pipes were flushed with saline and zeroed to atmosphere. The transducers were then connected to the catheters and patient information was entered into the system. The bladder was scanned using ultrasound for the presence of urine and if present it was removed using the catheter. The transducers were then equalized, and urodynamic trace was initiated. The bladder was filled with warmed normal saline solution at an initial rate of 10 ml/min. The rate was increased to 20–30 ml/min if the patient tolerated the infusion well.

The connections were checked by asking the patient to cough at the beginning of the test and subsequently after every 50–100 ml of infusion. The first sensation, strong sensation, and desire to micturate were recorded as per the International Continence Society (ICS) definition.⁷ The capacity of the bladder was marked digitally when the patient was unable to tolerate any further filling of the bladder. In patients with insensate bladder, the volume at

which the patient reported pain or discomfort was taken as the bladder capacity. Infusion volume was decided based on prevoid bladder volume measured using screening ultrasonogram. Once capacity was reached patient was asked to void into the uroflowmeter. During the storage phase of the test note was made of the compliance of the detrusor and the various capacities at which the first sensations were perceived by the patient.

The strong desire and capacity values were also noted. Compliance was calculated as the change in pressure per unit change in the volume. Detrusor overactivity, rectal contractions, and other urodynamic findings were noted during the filling phase. A note of leakage was also made, but none of the patients had demonstrable leak during filling. During the voiding phase, note was made of the detrusor pressure at the peak of uroflowmetry and the maximum detrusor pressures reached during the void. Electromyography activity of the pelvic floor/sphincter was noted during both phases. Pdet max was taken as a substitute for Pdet Qmax in patients who could not void.

These urodynamic parameters were recorded in a spreadsheet. After the procedure, the postvoid residual urine was also calculated and recorded. The calculation of postvoid residual volume was done by the urodynamic system using the subtraction algorithm (infused volume-voided volume). Catheters were gently removed, and postprocedural antibiotics were prescribed either empirically in the form of ciprofloxacin for 3 days if urine was sterile or based on the available urine culture report. All patients were advised regarding bladder care by the urologist and appropriate treatment was advised based on urodynamic findings wherever needed.

Statistical analysis

At the end of the study, the data were collected and master chart was prepared. The data were analyzed using SPSS Version 19.0 (Armonk, NY: IBM Corp). The clinical and magnetic resonance imaging (MRI) findings in the patients with and without bladder dysfunction were compared by the Chi-square test, Fisher's exact test, and independent *t*-test. Level of statistical significance was kept at $P < 0.05$ for all the tests at 95% of confidence interval.

Results

The mean age of presentation was 39.73 ± 15.19 years for the cohort. Patients were divided into two groups on the basis of the absence (Group 1; $n = 14$) or presence (Group 2; $n = 16$) of bladder dysfunction. There was no statistically significant difference between the two groups with respect to age distribution ($P = 0.196$), type of treatment (medical and/surgical) (0.088), and the number of smoking/nonsmoking patients ($P = 0.654$).

The frequency of symptoms at initial presentation and end of treatment are shown in Table 1.

Deformity angles were made a note of at followup and it was noted that initial mean deformity angle (14.2 ± 8.4) and mean deformity angle at 12 months (15.2 ± 10.2) were comparable and there was no statistically significant difference between patients of both the groups ($P = 0.541$).

On radiological assessment, number of vertebrae involved ($P = 0.260$), pulmonary involvement, region of involvement ($P = 0.306$), pattern of vertebral involvement ($P = 0.143$), presence of skip lesion ($P = 0.743$), disc involvement ($P = 0.222$), end plate sclerosis ($P = 0.431$), and end plate destruction ($P = 0.222$) were comparable in patients of both the groups [Figure 1].

MRI parameters observed in the study and subsequent changes with treatment in both the groups are shown in Table 2, Graphs 1-7, and Figure 2.

Four patients complained of frequency, three of urgency, two of hesitancy, three of retention, and four of on/off urge related incontinence at the start of the therapy. At 1 year, one patient complained of frequency, 1 hesitancy,

and 1 hesitancy with retention. The initial urodynamic assessment showed 7 patients (23.3%) had delayed sensations, 19 patients (63.3%) had normal sensations, and 4 patients (13.3%) had early sensations as per the ICS definition.⁷ Only one of these patients (3.3%) had decreased compliance while it was normal in the rest of the cases.

The mean bladder capacity was 434.90 ± 144.35 ml at initial assessment of the entire cohort. At the initial, 3rd month, 6th month, and 12th month assessment the mean bladder capacity of Group 2 16 cases (Group 2) was 449.00 ± 187.58 ml, 442.85 ± 168.87 ml, 418.31 ± 122.72 ml, and 421.18 ± 115.39 ml, respectively.

There was a significant improvement in the sensory parameters when initial and 12 months urodynamic parameters were compared ($P < 0.001$). The improvement in compliance and detrusor contractility was also found to be statistically significant at 12 months ($P < 0.001$) [Figure 3]. One patient with detrusor-sphincter dyssynergia showed complete resolution at 1 year [Table 3 and Graphs 8-11]. Of the 16 patients having

Table 1: Comparison of symptomatology in both the groups

Symptomatology	Initial presentation (n)		Final presentation (n)		<i>P</i> *	
	Group 1	Group 2	Group 1	Group 2	Initial <i>P</i> ₍₀₎	Final <i>P</i> ₍₁₂₎
Fever	12	16	0	2	0.118	0.171
Cough	7	10	1	1	0.491	0.547
Back pain	14	16	6	11	-	0.153
Deformity	1	8	3	8	0.011	0.185
Tenderness	14	16	5	12	-	0.030
Abscess	2	2	0	0	0.886	0.341
Sinus	1	1	0	0	0.922	-
Sensory deficit	7	14	2	8	0.025	0.038
ESR	49.12	47.67	18.2	15.1	0.306	0.143

*Chi-Square test. *P*₍₀₎=Statistical significance between Group 1 and Group 2 at initial presentation using, *P*₍₁₂₎=Statistical significance between Group 1 and Group 2 at 12 months. ESR=Erythrocyte sedimentation rate

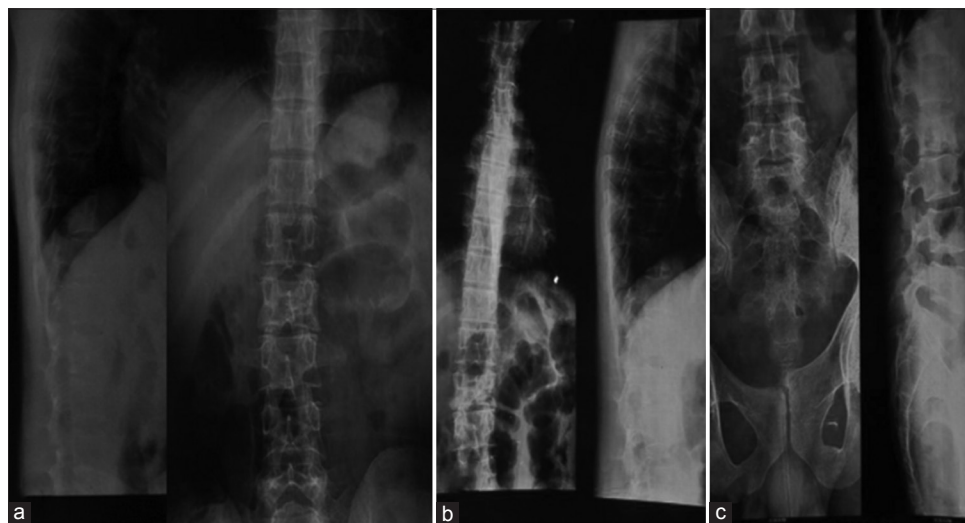
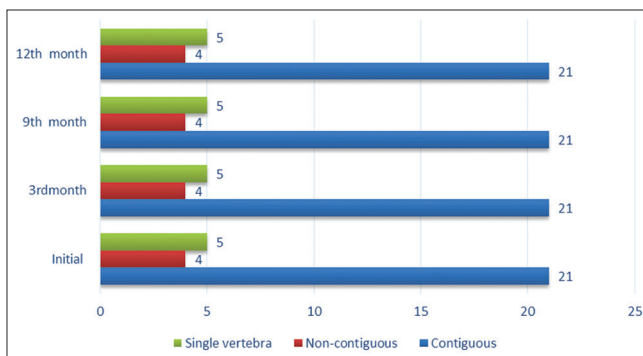
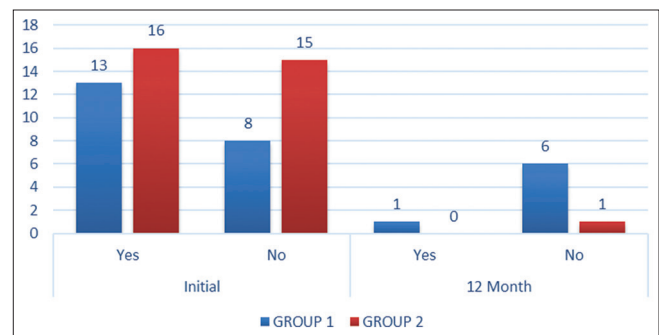
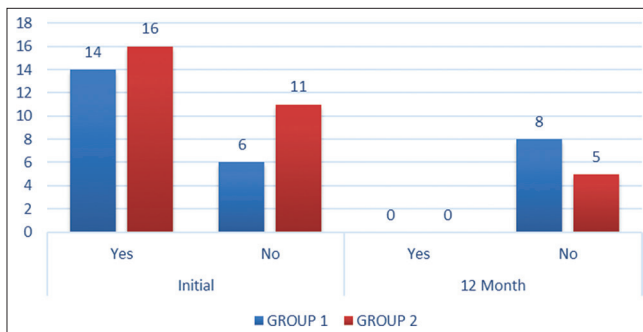
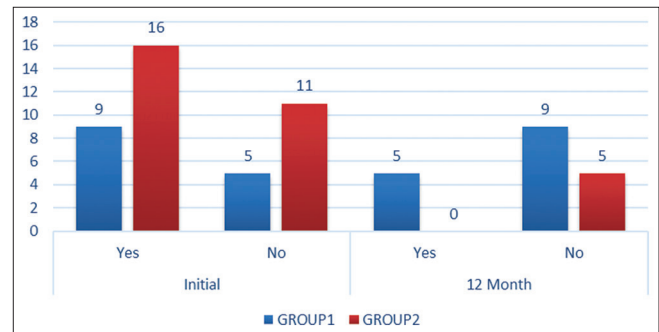
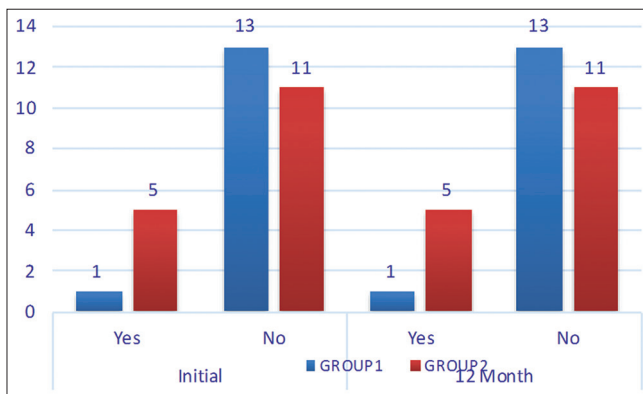
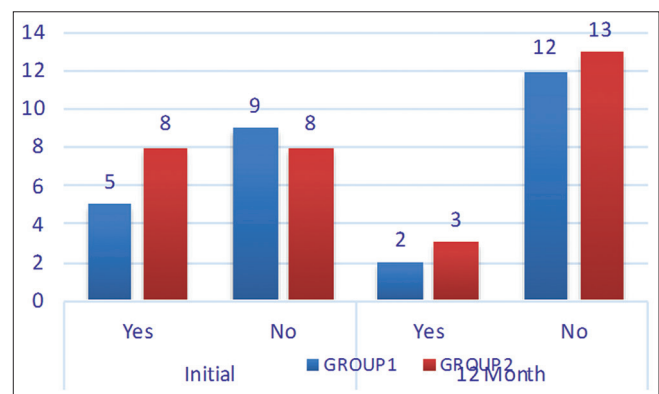


Figure 1: Plain radiographs of the patient with tubercular spondylitis (L2–L3) with neurological involvement (American spinal injury impairment scale B) and bladder comorbidity at presentation, 6 months, and 12 months. Initial X-rays show typical paradiscal involvement of two vertebrae with disc involvement and endplate destruction (a) 6 months (b) and 12 months (c) X-rays show healing with endplate sclerosis and reduced disc height

Table 2: Comparison of changes in magnetic resonance imaging parameters in both the groups

Findings on MRI	Initial number of patients		Final number of patients		P^*	
	Group 1	Group 2	Group 1	Group 2	Initial (P_1)	Final (P_{12})
Number of vertebra involved	31	40	30	44	0.182	0.093
End plate erosion	13	16	8	15	0.277	0.018
Marrow edema	14	16	6	11	-	0.151
Reduction in disc height	9	16	5	11	0.009	0.050
Posterior element involvement	1	5	1	5	0.044	0.044
Sub-ligamentous spread	9	10	2	4	0.919	0.464
Extradural component	5	8	2	3	0.403	0.743
Extent of sub-ligamentous spread (vertebrae)	26	33	6	10	0.464	0.923
Extent of epidural collection (vertebrae)	11	24	0	8	0.487	0.401
Nerve root involvement	2	9	0	2	0.017	0.017

*Chi-square test. $P_{(1)}$ =Statistical significance between Group 1 and Group 2 at initial presentation using, $P_{(12)}$ =Statistical significance between Group 1 and Group 2 at 12 months. MRI=Magnetic resonance imaging

**Graph 1: Pattern of vertebral involvement on different followup times****Graph 2: End plate erosion at initial and 12 months in both groups****Graph 3: Bone marrow edema at initial and 12 months in both groups****Graph 4: Reduction in disc height initial and 12 months in both groups****Graph 5: Posterior element involvement at initial and 12 months in both groups****Graph 6: Extradural spread at initial and 12 months in both groups**

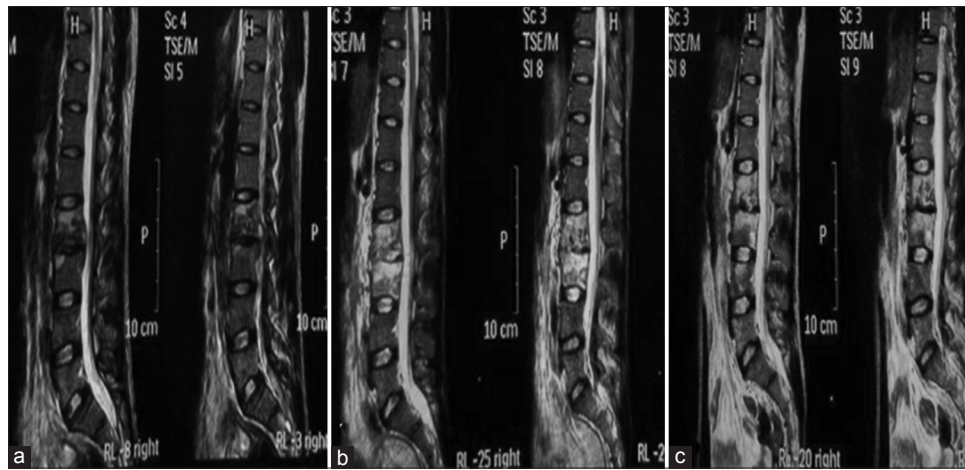
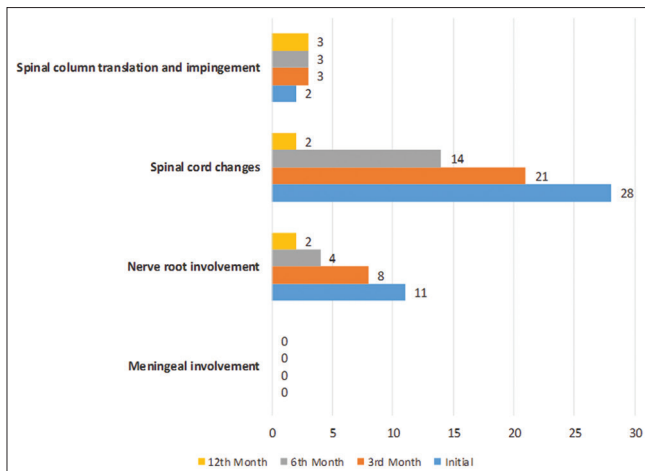
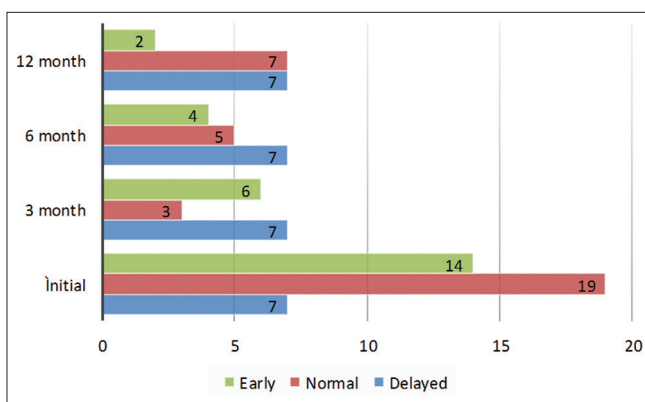


Figure 2: T2-weighted magnetic resonance imaging images of the same patient. Initial magnetic resonance imaging shows paradiscal involvement of 2 vertebrae with end plate erosion, bone marrow edema, sub ligamentous spread and reduction in disc height. (a) At 6 months edema and sub ligamentous collection are absent; and disc space has further narrowed. (b) At 12 months completely healed tuberculosis with disc space narrowing (c)



Graph 7: Various components of intracanalicular spread at various followup visits in the cohort



Graph 8: Bladder sensation at various followup visits

urodynamic involvement 13 patients (81.25%) had improvement in variables under study and 3 cases (18.75%) did not show improvement.

On analyzing (using paired students *t*-test) urological improvement with respect to neurological improvement, it

was found that with treatment, patients with improvement in urological symptoms, i.e., normal sensations, compliance, detrusor activity, and sphincter activity were categorized mostly in ASIA Grade C, D, or E (in increasing order), thus depicting neurological improvement as well. The neurological correlation (ASIA Grade) with bladder profile is shown in Table 4. Comparing neural and functional recovery in both groups, Group 2 patients showed poor recovery both at 6 months ($P = 0.017$) and 1 year ($P = 0.044$).

Discussion

Significant micturition problems observed in the present study highlight the importance of early recognition of these in patients with spinal TB. Other studies had also reported 25%–50% incidence bladder dysfunctions in patients with spinal TB.^{2,8} An incidence of 17%–71% of urinary symptoms and urodynamic dysfunctions had been reported in tubercular meningitis.^{9–11}

Comparison of both the groups in the present study showed a deformity at initial presentation and tenderness at the end of treatment in both groups to be statistically significant indicating that patients with bladder comorbidities had higher deformity at presentation ($P = 0.011$) and persisting tenderness by the end of treatment ($P = 0.030$). The difference in sensory deficit, in both groups, was found to be statistically significant ($P_1 = 0.025$, $P_{12} = 0.038$). This indicated that there was more likely an associated sensory deficit in patients with urodynamic abnormalities as compared to the other group.

Overall improvement was observed on serial urodynamics in 13 (81.3%) patients. On comparison between the bladder involvement at initial and final followup, in patients belonging to Group 2, the improvement was found to be statistically significant ($R = 3.465$, $P = 0.034$). Analysis of three patients (18.75%) who did not improve by the end

Table 3: Various urodynamic parameters at initial, 3rd, 6th, 12th month

Urodynamic features	Initial assessment (n=30), n (%)	Assessment at 3 rd month (n=16), n (%)	Assessment at 6 th month (n=16), n (%)	Assessment at 12 th month (n=16), n (%)
Sensations				
Delayed	7 (23.3)	7 (43.8)	7 (43.8)	7 (43.8)
Normal	19 (63.3)	3 (18.8)	5 (31.3)	7 (43.8)
Early	4 (13.3)	6 (37.5)	4 (25.0)	2 (12.5)
Compliance				
Decreased	1 (3.3)	1 (6.3)	1 (6.3)	1 (6.3)
Normal	29 (96.7)	15 (93.8)	15 (93.8)	15 (93.8)
Detrusor activity				
Underactive	7 (23.3)	8 (50.0)	8 (50.0)	6 (37.5)
Normal	19 (63.3)	5 (31.3)	6 (37.5)	8 (50.0)
Overactive	4 (13.3)	3 (18.8)	2 (12.5)	2 (12.5)
Sphincter activity				
Dys-synergic	4 (13.3)	1 (6.3)	1 (6.3)	1 (6.3)
Synergic	26 (86.6)	15 (93.8)	15 (93.8)	15 (93.8)

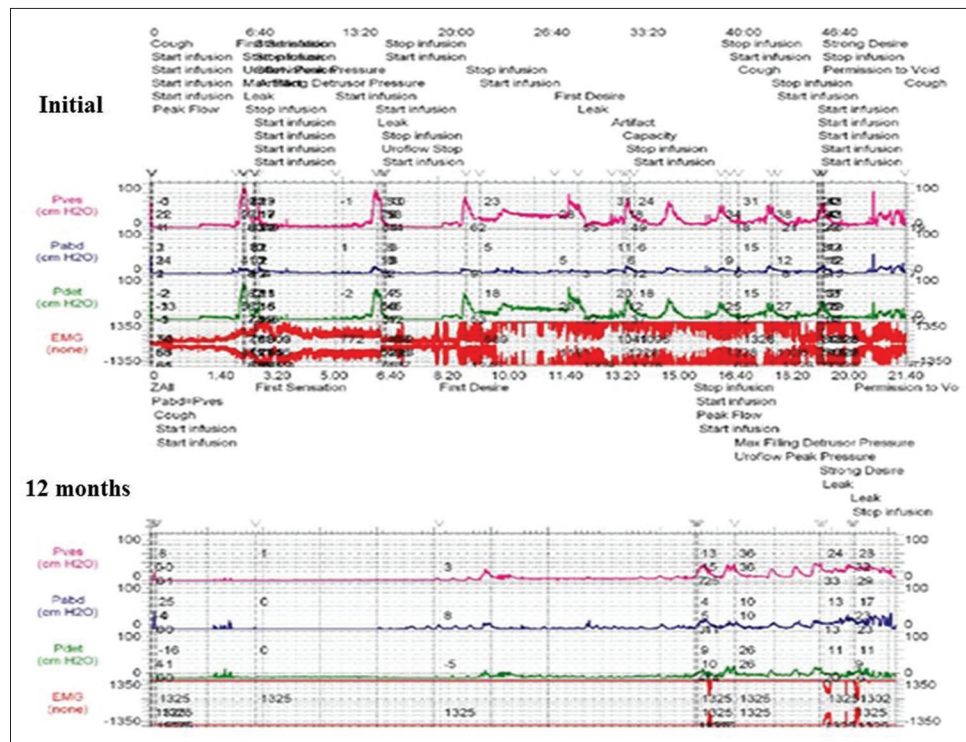
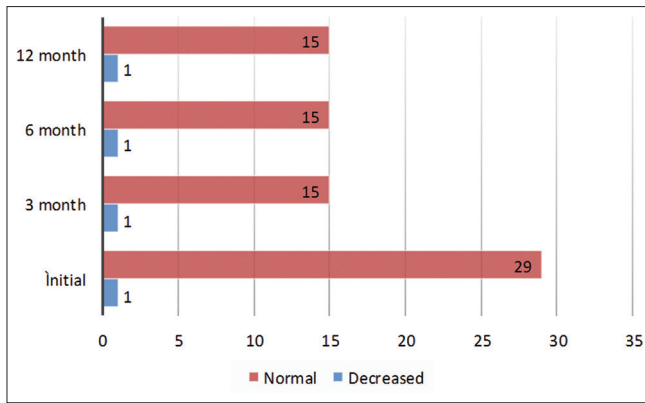


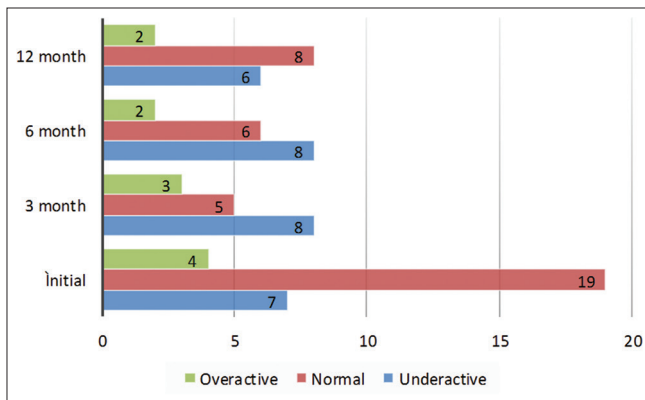
Figure 3: Urodynamic study of the same patient. Patient had early sensations, normal compliance, overactive detrusor and dyssynergic sphincter initially. At 12 months patient improved neurologically. Urodynamically sensations remained early, normal compliance, detrusor was underactive, and sphincter became synergic

of 12 months of chemotherapy showed one had persistent bladder outlet obstruction symptoms and myelomalacia on MRI, one patient diagnosed with a case of multidrug-resistant TB, and case was noncompliant to treatment due to ATT induced hepatitis. All these patients still had some neural deficit. In a study by Kalita *et al.* UDS showed detrusor hyperreflexia (DH) with high-pressure voiding was present in six patients (20%), detrusor areflexia in four patients (13.3%), normal study in 1 (3.33%) and increased postvoid residual urine in the remaining patients (63.3%).² The symptoms of bladder dysfunction

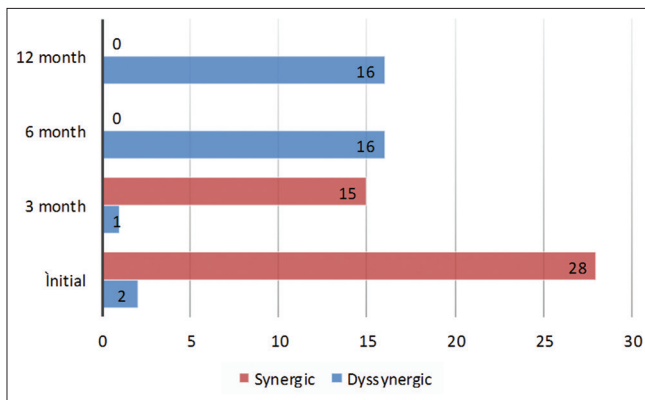
as assessed by the American urological association symptom score revealed significant improvement in all the patients at 6 ($P = 0.0001$) and 12 months ($P = 0.0001$).² In another study by Kalita *et al.* in 18 cases of transverse myelitis, urodynamic studies showed an areflexic or hypocontractile bladder in 10, DH with poor compliance in two, and detrusor sphincter dyssynergia in three. Early abnormal urodynamic findings commonly persisted at the six and 12 months examinations. Persistent abnormalities included DH, dyssynergia, and areflexic bladder.¹² Gupta and Tally in 79 patients with nontraumatic myelopathies



Graph 9: Compliance at various follow up visits



Graph 10: Detrusor activity at various followup visits



Graph 11: Sphincter activity at various followup visits

reported that UDS showed 71.4% of patients (40/56) had neurogenic detrusor overactivity (NDO) with or without detrusor sphincter dyssynergy (DSD) with lesion above D10; only 52.9% of 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.¹¹

Similar observations have also been made in the traumatic conditions also. In a study by Weld and Dmochowski, of the 196 patients with suprasacral

injuries, 186 (94.9%) demonstrated hyperreflexia and/or detrusor-sphincter dyssynergia, 82 (41.8%) had low bladder compliance (<12.5 mL/cm H₂O), and 79 (40.3%) had high detrusor leak point pressures (>40 cm H₂O). Of the 14 patients with sacral injuries, 12 (85.7%) manifested areflexia, 11 (78.6%) had low compliance, and 12 (85.7%) had high leak point pressures. Of the 33 patients with combined suprasacral and sacral injuries, urodynamic studies showed 23 with hyperreflexia and/or detrusor-sphincter dyssynergia (67.7%), 9 with areflexia (27.3%), 19 (57.6%) with low compliance, and 20 (60.6%) with high leak point pressures.¹³

It was observed that change in marrow edema ($R = 0.34$), paravertebral collections ($R = 0.51$), sub-ligamentous spread ($R = 0.22$), extradural component ($R = 0.38$), endplate erosion and discitis ($R = 0.5$) are the prognostic indicators of response to chemotherapy along with neurological signs of recovery gender using the Chi-square test. However, urodynamic improvement does not absolutely correlate with aforesaid features. The principle findings in MRI that correlate well with the behavior of bladder comorbidity with treatment include nerve root involvement, posterior element involvement, reduction in disc height and endplate erosion; but there are no definite prognosticating factors that clearly relate with the outcome of bladder comorbidities. The neurological involvement improved with chemotherapy and well related to clinical, radiological, and urological recovery. When comparing neural and functional recovery in both groups, Group 2 patients showed poor recovery both at 6 months and 1 year. Kalita *et al.* also concluded that patients with micturition disturbances had a poorer functional recovery at 1 year compared to those without micturition disturbances.² However, Menon *et al.* reported that in myelopathies, neurogenic bladder patterns had no significant correlation with functional and neurological recovery.³ Gupta and Tally reported as the patients showing significant neurological recovery may still continue to have neurogenic bladder and vice versa, all nontraumatic myelopathies patients need to be followed up long term for effective management of bladder and to avoid complications. No statistically significant correlation was found ($P > 0.05$) between detrusor behavior and the level, severity (ASIA impairment scale) of spinal injury, or gender using the Chi-square test.¹¹

To avoid urinary complications, bladder dysfunctions associated with TB of the spine need multidisciplinary approach (pharmacological, surgical, and behavioral therapy). The patients with hypocontractile detrusor were treated with cholinergics (bethanechol) and clean intermittent catheterization. In patients where detrusor pressures were low and postvoid residual urine was minimal, only cholinergics were prescribed and detrusor pressures at maximum flow (P_{det}/Q_{max}) were followed up. Patients with detrusor overactivity were managed with anticholinergic agents (solifenacin or darifenacin) for duration of 3–6 months

Table 4: Correlation of urodynamics with initial and change in American Spinal Injury Impairment Scale grades at 1 year

Urodynamic features	Grade A		Grade B		Grade C		Grade D		Grade E	
	Initial	12 month	Initial	12 month	Initial	12 month	Initial	12 month	Initial	12 month
Sensations										
Delayed	2	0	1	0	3	3	1	3	0	0
Normal	-	0	0	0	3	1	9	1	6	19
Early	-	0	0	0	3	0	1	0	1	2
Compliance										
Decreased	0	0	1	0	-	0	0	1	0	0
Normal	2	0	0	0	9	4	11	3	7	21
Detrusor activity										
Underactive	2	0	1	0	2	2	1	2	1	2
Normal	0	0	0	0	5	1	9	2	5	19
Overactive	0	0	0	0	2	1	1	0	1	0
Sphincter activity										
Dys-synergic	1	1	1	0	2	0	0	0	0	0
Synergic	0	0	1	0	7	4	11	4	7	21

depending on the severity of symptoms and urodynamic assessment was performed at each followup. One (3.33%) of patient with evidence on bladder outlet obstruction on urodynamic evaluation was managed with alpha blockers. The patient improved on followup. Four patients (13.33%) were treated with behavioral therapy and were found to improve with followup. Three (10%) of our patients demonstrated urodynamic evidence of detrusor hyperactivity with impaired contractility. These patients were also managed with anticholinergic agents and clean intermittent catheterization. The patients were found to have an improvement of bladder related co morbidity and other symptomatology with pharmacological and behavioral therapy.

Conclusion

Significant bladder comorbidity is associated with spinal TB and its presence can be recognized as a poor prognostic factor. Urological morbidity is strongly linked to the nerve root and; posterior element involvement; reduction in disc height; and end plate erosion. Clinical/neurological improvement correlates with marked radiological and urological improvement. However, the radiologic prognostic indicators of response to chemotherapy do not absolutely correlate with urodynamic improvement.

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Conflicts of interest

There are no conflicts of interest.

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