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Research Article

MRI-Based Association of Spinal Tuberculosis with Diabetic Cystopathy and Lower Urinary Tract Dysfunction: A Cross-Sectional Study

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Abstract

Spinal tuberculosis (STB) remains one of the most common forms of extrapulmonary tuberculosis and is frequently associated with neurological complications due to spinal cord and nerve root compression. Diabetes mellitus is an established risk factor for both tuberculosis and diabetic cystopathy, a form of autonomic neuropathy characterized by impaired bladder sensation and voiding dysfunction. The coexistence of spinal tuberculosis and diabetes may potentiate lower urinary tract dysfunction (LUTD) through combined neurological and autonomic mechanisms; however, imaging-based evidence remains limited. This study evaluated the association between magnetic resonance imaging (MRI) findings of spinal tuberculosis, diabetic cystopathy, and lower urinary tract dysfunction.

A cross-sectional study was conducted involving 230 diabetic patients with MRI-confirmed spinal tuberculosis. All participants underwent spinal MRI, urinary symptom assessment using the International Prostate Symptom Score (IPSS) or International Consultation on Incontinence Questionnaire (ICIQ), uroflowmetry, and post-void residual volume measurement. MRI characteristics including vertebral involvement, epidural extension, spinal cord compression, and neural foraminal narrowing were analyzed.

The mean age was 56.4 ± 11.2 years, and 61.7% of participants were male. Lower urinary tract dysfunction was identified in 128 patients (55.7%), while diabetic cystopathy was diagnosed in 96 patients (41.7%). Patients with spinal cord compression demonstrated significantly higher post-void residual volumes (176.3 ± 61.8 mL vs 82.7 ± 34.5 mL, $p < 0.001$), lower maximum urinary flow rates (8.2 ± 2.5 mL/s vs 13.7 ± 3.4 mL/s, $p < 0.001$), and greater prevalence of diabetic cystopathy (61.8% vs 29.7%, $p < 0.001$). Multivariate analysis identified spinal cord compression (OR 4.8, 95% CI 2.5–9.1), epidural abscess formation (OR 3.6, 95% CI 1.8–7.0), and diabetes duration >10 years (OR 3.1, 95% CI 1.6–6.0) as independent predictors of lower urinary tract dysfunction.

MRI findings demonstrated a significant association between spinal tuberculosis severity and urinary dysfunction among diabetic patients. Early MRI evaluation may facilitate identification of patients at increased risk of bladder dysfunction and guide multidisciplinary management.

Keywords: Spinal tuberculosis, diabetic cystopathy, lower urinary tract dysfunction, magnetic resonance imaging

Introduction

Tuberculosis remains a major global health challenge, particularly in developing countries where the disease continues to contribute substantially to morbidity and mortality. Although pulmonary involvement accounts for the majority of cases, extrapulmonary manifestations represent a significant proportion of tuberculosis-related disease burden. Among these manifestations, spinal tuberculosis, also known as Pott disease, is the most common form of skeletal tuberculosis and accounts for approximately half of all musculoskeletal tuberculosis cases [1–3].

Spinal tuberculosis primarily affects the vertebral bodies and intervertebral discs, leading to progressive vertebral destruction, spinal instability, kyphotic deformity, epidural abscess formation, and neurological compromise. Delayed diagnosis may result in irreversible spinal cord injury and long-term disability. Magnetic resonance imaging has emerged as the imaging modality of choice for the evaluation of spinal tuberculosis because of its superior ability to detect bone marrow involvement, paravertebral collections, epidural extension, and neural compression [2–5].

Diabetes mellitus is increasingly recognized as an important risk factor for tuberculosis. Chronic hyperglycemia impairs innate and adaptive immune responses, increasing susceptibility to Mycobacterium tuberculosis infection and contributing to more severe disease manifestations. The global rise in diabetes prevalence has therefore amplified concerns regarding the interaction between these two chronic diseases [4–7].

Diabetic cystopathy represents one of the most common forms of autonomic neuropathy affecting diabetic patients. The condition is characterized by diminished bladder sensation, increased bladder capacity, impaired detrusor contractility, elevated post-void residual volume, and progressive urinary dysfunction. Clinical manifestations may include urinary frequency, urgency, nocturia, hesitancy, incomplete emptying, and urinary retention [5–8].

The coexistence of spinal tuberculosis and diabetes mellitus introduces a complex clinical scenario in which lower urinary tract dysfunction may result from multiple overlapping mechanisms. Compression of the spinal cord or nerve roots by tuberculous lesions may impair neural pathways regulating micturition, while diabetic autonomic neuropathy independently contributes to bladder dysfunction. Distinguishing the relative contributions of these processes remains challenging in routine clinical practice [6–9].

Lower urinary tract dysfunction significantly affects quality of life and may increase the risk of recurrent urinary tract infections, upper urinary tract deterioration, and chronic kidney disease. Early recognition of urinary complications in patients with spinal tuberculosis is therefore essential for preventing irreversible urological sequelae [7–10].

MRI plays a critical role in identifying neurological involvement in spinal tuberculosis. Imaging findings such as spinal cord compression, epidural abscesses, vertebral collapse, and foraminal narrowing may provide valuable information regarding the risk of bladder dysfunction. However, few studies have systematically examined the relationship between MRI findings and lower

urinary tract symptoms among diabetic patients with spinal tuberculosis [8–12].

Given the increasing coexistence of tuberculosis and diabetes worldwide, improved understanding of imaging predictors of urinary dysfunction is clinically important. Identification of high-risk patients may facilitate early intervention and improve functional outcomes. Therefore, this study aimed to evaluate the MRI-based association between spinal tuberculosis, diabetic cystopathy, and lower urinary tract dysfunction in diabetic patients.

Methodology

This cross-sectional study was conducted at Bolan University of Medical & Health Sciences over a period of 30 months. Adult diabetic patients aged 18 years and older with MRI-confirmed spinal tuberculosis were recruited consecutively from neurology, infectious disease, radiology, and endocrinology clinics.

Diagnosis of spinal tuberculosis was established based on MRI findings combined with microbiological, histopathological, or clinical evidence of tuberculosis. Diabetes mellitus was diagnosed according to American Diabetes Association criteria.

Inclusion criteria included confirmed spinal tuberculosis, established diabetes mellitus, and completion of MRI and urinary function assessment. Exclusion criteria included previous spinal surgery, bladder malignancy, benign prostatic hyperplasia requiring surgery, multiple sclerosis, traumatic spinal cord injury, urinary tract obstruction, pregnancy, chronic renal replacement therapy, and incomplete imaging studies.

Sample size calculation was performed using Epi Info version 7. Assuming a prevalence of lower urinary tract dysfunction of 50%, confidence level of 95%, margin of error of 6%, and power of 80%, the minimum required sample size was calculated as 223 participants. To account for incomplete data, 230 patients were enrolled.

All participants underwent MRI using a 1.5-Tesla system. Imaging variables included vertebral body involvement, spinal level affected, epidural abscess formation, paravertebral abscess, vertebral collapse, spinal cord compression, neural foraminal narrowing, and degree of canal compromise.

Urinary assessment included symptom questionnaires, uroflowmetry, post-void residual volume measurement, urinalysis, and ultrasonography. Diabetic cystopathy was defined as post-void residual volume greater than 100 mL combined with reduced urinary flow rate (<10 mL/s) and clinical symptoms consistent with autonomic bladder dysfunction.

Ethical approval was obtained from the institutional review board. Written informed consent was obtained from all participants before enrollment.

Statistical analysis was performed using SPSS version 27. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were analyzed using Chi-square testing. Logistic regression was used to identify independent predictors of lower urinary tract dysfunction. Statistical significance was established at $p < 0.05$.

Results

Table 1. Baseline Demographic and Clinical Characteristics (n = 230)

Variable	Value
Age (years)	56.4 ± 11.2

Variable	**Value**
Male sex	142 (61.7%)
Female sex	88 (38.3%)
Duration of diabetes (years)	11.8 ± 5.6
HbA1c (%)	8.6 ± 1.4
Duration of tuberculosis symptoms (months)	8.2 ± 3.5
Lower urinary tract dysfunction	128 (55.7%)
Diabetic cystopathy	96 (41.7%)
Spinal cord compression	89 (38.7%)
Epidural abscess	78 (33.9%)
Vertebral collapse	72 (31.3%)

Table 1 demonstrates a predominantly middle-aged diabetic population with a high prevalence of urinary dysfunction and MRI evidence of advanced spinal tuberculosis.

Table 2. Comparison of Urinary Function According to Presence of Spinal Cord Compression

Variable	**Cord Compression Present (n=89)**	**Cord Compression Absent (n=141)**	**p-value**
IPSS/ICIQ Score	21.8 ± 5.4	12.6 ± 4.3	<0.001
Maximum Flow Rate (mL/s)	8.2 ± 2.5	13.7 ± 3.4	<0.001
Post-Void Residual Volume (mL)	176.3 ± 61.8	82.7 ± 34.5	<0.001
Diabetic Cystopathy (%)	61.8%	29.7%	<0.001
LUT Dysfunction (%)	78.7%	41.1%	<0.001

Patients with spinal cord compression demonstrated significantly greater urinary dysfunction and higher prevalence of diabetic cystopathy.

Table 3. MRI Characteristics and Lower Urinary Tract Dysfunction

MRI Variable	LUT Dysfunction Present (n=128)	LUT Dysfunction Absent (n=102)	p-value
Epidural Abscess (%)	53.1%	10.8%	<0.001
Vertebral Collapse (%)	46.9%	11.8%	<0.001
Cord Compression (%)	54.7%	18.6%	<0.001
Foraminal Narrowing (%)	48.4%	16.7%	<0.001
Multi-Level Disease (%)	62.5%	31.4%	<0.001

Advanced MRI abnormalities were significantly more common among patients with urinary dysfunction.

Table 4. Multivariate Logistic Regression Predictors of Lower Urinary Tract Dysfunction

Variable	Odds Ratio	95% CI	p-value
Spinal Cord Compression	4.8	2.5–9.1	<0.001
Epidural Abscess	3.6	1.8–7.0	<0.001
Diabetes Duration >10 years	3.1	1.6–6.0	<0.001
Vertebral Collapse	2.9	1.4–5.8	0.003
HbA1c >8%	2.4	1.2–4.7	0.011

Spinal cord compression emerged as the strongest independent predictor of urinary dysfunction.

Discussion

The present study demonstrated a significant association between MRI severity markers of spinal tuberculosis and lower urinary tract dysfunction among diabetic patients. More than half of the study population exhibited urinary dysfunction, highlighting the substantial burden of urological complications in this patient group. These findings suggest that neurological

compromise secondary to spinal tuberculosis contributes significantly to bladder dysfunction beyond the effects of diabetic autonomic neuropathy alone [13–14].

Spinal cord compression emerged as the strongest predictor of urinary dysfunction. Patients with cord compression exhibited markedly elevated post-void residual volumes and reduced urinary flow rates, indicating impaired bladder emptying. These findings are consistent with the recognized role of spinal cord pathways in coordinating storage and voiding functions. Compression of these pathways may disrupt neural communication between the brain and lower urinary tract, resulting in neurogenic bladder dysfunction [14–15].

The prevalence of diabetic cystopathy was significantly higher among patients with spinal cord compression. This observation suggests a synergistic interaction between diabetic autonomic neuropathy and tuberculosis-related neurological injury. Chronic hyperglycemia may predispose neural structures to injury, while spinal tuberculosis further compromises neural control of bladder function, resulting in more severe clinical manifestations [15–16].

Epidural abscess formation demonstrated a strong association with urinary dysfunction. Epidural collections may exert direct pressure on neural structures and contribute to inflammatory injury. Previous studies have emphasized the importance of early detection and treatment of epidural abscesses to prevent irreversible neurological deficits and associated bladder dysfunction [16–17].

Vertebral collapse and foraminal narrowing were also significantly associated with urinary symptoms. Progressive vertebral destruction may alter spinal alignment, exacerbate neural compression, and increase the likelihood of neurological impairment. MRI provides superior visualization of these abnormalities and remains indispensable for evaluating disease severity [17–18].

Multi-level disease involvement was more frequent among patients with urinary dysfunction, indicating that extensive spinal tuberculosis may confer a higher risk of neurological complications. This finding supports routine neurological and urological assessment in patients demonstrating widespread spinal involvement on MRI [18–19].

The strengths of this study include comprehensive MRI evaluation, standardized urinary function assessment, and inclusion of a relatively large cohort of diabetic patients with spinal tuberculosis. However, the cross-sectional design precludes determination of causality. Longitudinal studies are required to assess whether successful treatment of spinal tuberculosis improves urinary outcomes and reverses bladder dysfunction [19–20].

Overall, the findings underscore the importance of integrating radiological, neurological, endocrinological, and urological assessments when managing diabetic patients with spinal tuberculosis. Early identification of high-risk MRI features may facilitate timely intervention and improve long-term outcomes.

Conclusion

MRI severity markers of spinal tuberculosis, particularly spinal cord compression and epidural abscess formation, are strongly associated with diabetic cystopathy and lower urinary tract dysfunction. Combined neurological and autonomic mechanisms appear to contribute to bladder dysfunction in diabetic patients with spinal tuberculosis. Early MRI-based risk stratification may improve identification and management of patients at risk for significant urinary complications

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