Symptomatic Urinary Tract Infection in Patients with Type 2 Diabetes: A Prospective Study

Tauseef Nabi
Consultant, Department of Endocrinology, MMIMSR, Ambala, Haryana, India

Abstract

Background: Patients with type 2 diabetes (T2D) are at increased risk of urinary tract infection (UTI). **Objective:** The aim was to study clinical, etiological profile, complications, and follow-up of symptomatic UTI in T2D patients and the effect on glycemic control and renal parameters. **Materials and Methods:** This was a hospital-based prospective study done on admitted 200 T2D symptomatic UTI patients. Various clinical, biochemical parameters and urine examination and culture were monitored. All patients were followed for 6 months with respect to the number of UTIs, glycemic control, and renal parameters. **Results:** UTI was common in females (81%) compared to males (19%). Lower UTI (cystitis) was present in 55.5% and pyelonephritis 44.5%, emphysematous pyelonephritis in 9.5%, and bacteremia in 58.1% of UTI patients. Bacteriuria was present in 69%. *Escherichia coli* (55%) was the most common organism isolated from urine culture. Severe hyperglycemia was present in 83.5%, diabetic ketoacidosis in 8%, hyperglycemic hyperosmolar state in 13%, shock in 14.5%, and multiorgan dysfunction syndrome in 10.5% of UTI patients. UTI in females was significantly associated with postmenopausal state, longer duration of diabetes, retinopathy, nephropathy, poor glycemic control, acute kidney injury, cystopathy, and upper UTI. The prevalence of recurrent UTI was 39.6%. Recurrent UTI patients had significantly higher glycosylated hemoglobin at follow-up than at baseline, but renal parameters did not improve despite intensive treatment. **Conclusion:** Symptomatic UTI in T2D patients is common in postmenopausal females with longer duration of diabetes, poor glycemic control, cystopathy, and chronic diabetic complications. Recurrent UTI patients have poor glycemic control on follow-up while renal parameters do not improve.

Keywords: Glycemic control, renal parameters, symptomatic urinary tract infection, type 2 diabetes, urinary tract infections

Introduction

Diabetes has become a major health challenge worldwide. As per the International Diabetes Federation 2019 report, India is harboring 77 million patients with diabetes and by 2045 will have about 134.2 million.[1] Patients with type 2 diabetes (T2D) are at increased risk of infections, with the urinary tract being the most frequent site,[2,3] and good diabetic control reduces this risk. Urinary tract infection (UTI) in diabetes is a common cause of morbidity and can lead to significant mortality.

UTI is an inflammatory response of the urothelium to the bacterial invasion, which is normally free of bacteria and is usually associated with bacteriuria and pyuria. UTI affects women more commonly than men. The spectrum of UTI ranges from asymptomatic bacteriuria to lower UTI (cystitis) and pyelonephritis. Severe complications of UTI, such as emphysematous cystitis and pyelonephritis, renal abscesses, and renal papillary necrosis, occur more frequently in T2D than in the general population.[4]

The high rates of over-the-counter and broad-spectrum antibiotic prescription lead to the development of antibiotic-resistant urinary pathogens.[5] Symptoms of UTI are similar to patients without diabetes, though some patients with diabetic neuropathy may have altered clinical signs. Factors that were found to enhance the risk for UTI in patients of diabetes include age, metabolic control, and long-term complications, primarily diabetic nephropathy and cystopathy.[6]

The most common pathogens isolated from the urine of T2D with UTI are *Escherichia coli*, other Enterobacteriaceae

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Address for correspondence: Dr. Tauseef Nabi, E 32, MMIMSR, Ambala, Haryana, India.
E-mail: dr.tauseefnabi@gmail.com

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such as *Klebsiella* spp., *Proteus* spp., *Enterobacter* spp., and Enterococci.[7] A urine culture should be obtained in all cases of suspected UTI in patients with diabetes, before initiation of treatment.

Patients of T2D with UTI usually present with hypo- or hyperglycemia, or hyperglycemic hyperosmolar state (HHS), or even diabetic ketoacidosis (DKA).[8] Higher glucose concentrations in urine may promote the growth of pathogenic bacteria.[9] Impairments in the immune system, including humoral, cellular, and innate immunity, may contribute to the pathogenesis of UTI in diabetes.[10]

UTI in diabetes is the most common cause of inpatient admissions. UTI in diabetes is often given less importance. Patients with UTI should be treated aggressively and optimal glycemia maintained. Lack of proper follow-up and long-term complications of symptomatic UTI in patients with diabetes have not been fully addressed. The effect of symptomatic UTI on glycemic and renal parameters has also not been given consideration in studies. Therefore, with this study, we looked at the clinical profile, complications, and follow-up of admitted acute symptomatic UTI in patients with T2D and the effect on glycemic control and renal parameters.

Materials and Methods

This was a hospital-based prospective study of adult T2D patients attending the tertiary care center in North India. The study was approved by the institutional ethical committee. All the recruited subjects provided informed consent.

Study subjects

The study recruited consecutive 200 symptomatic UTI patients admitted to the endocrinology department, and they were followed for 6 months. This study was conducted over a period of 3 years from August 2015 to August 2018. All patients were interviewed at baseline using a standardized questionnaire regarding the number of UTIs within the previous year, urinary tract surgery, marital status, and menopausal status in females. A detailed physical examination of the subjects was carried based on a study protocol. The eligibility criteria for including the subject in the study were as follows: both male and female T2D patients having age >30 years. The exclusion criteria were as follows: (i) other types of diabetes, (ii) recent hospitalization/surgery, (iii) antimicrobial use within previous 14 days, (iv) immunocompromised states – HIV, malignancy, patients on steroids, and transplant recipients, (v) urinary tract surgery/instrumentation, and (vi) catheterized patients.

Detailed study design

Clinical and biochemical parameters

Clinical parameters including duration of diabetes, complications of diabetes, drug therapy, and clinical symptomatology, especially urinary complaints and comorbidities, were recorded. Complete blood count (CBC), renal function test (RFT), fasting blood glucose (FBG) and 2-h blood glucose postprandial (PP) , 24-h urinary protein estimation, and glycosylated hemoglobin (HbA1c) were estimated at baseline and at 6 months. HbA1c was measured by column chromatography (Bio-Rad, Richmond, CA). Ultrasonography (USG) of the abdomen was done in all admitted patients. Blood culture and noncontrast computed tomography abdomen were done as per requirement.

Urine examination and culture sensitivity

Voided, clean-catch, and midstream urine samples were collected from patients in a sterile wide-mouth container for routine urine analysis and culture sensitivity at baseline and at 6 months. Symptomatic UTI patients were divided into lower UTI (cystitis) (dysuria, frequency of urination, urgency, and/or abdominal discomfort) and upper UTI (pyelonephritis) (fever [>38.3°C], flank pain, nausea/vomiting, renal tenderness, and USG evidence of pyelonephritis). Emphysematous pyelonephritis (EPN) was defined when imaging showed characteristic features of gas. The detailed methodology has been described previously.[11]

Definitions

Pyuria (defined as ≥10 leukocytes/mm^3) and hematuria (defined as ≥3 red blood cells/high-power field) were detected by microscopic examination. Obesity was defined as body mass index ≥25 kg/m2 as per the South Asian criteria; uncontrolled hypertension was defined as systolic blood pressure of ≥140 or diastolic blood pressure of ≥90 mmHg; proteinuria was defined as 24-h urinary protein ≥150 mg, leukocytosis as total leukocyte count >10 × 103/μL. Acute kidney injury (AKI) was defined as rise in serum creatinine by 0.3 mg/dl from baseline or absolute value ≥1.5 mg/dl after excluding CKD. DKA and HHS defined as per the American Diabetes Association guidelines. Severe hyperglycemia, when blood glucose is ≥300 mg/dl. Cystopathy was defined as decreased bladder sensation and postvoid residual urine was >150 ml on USG. Shock and multiorgan dysfunction syndrome (MODS) were defined as per the Infectious Diseases Society of America guidelines. Estimated glomerular filtration rate (eGFR) was calculated by the Modification of Diet in Renal Disease.

Management protocol

UTI patients with mild-moderate symptoms were treated with oral antibiotics. Treatment with broad-spectrum empiric antibiotics was initiated in patients with severe symptoms, hemodynamic instability, or metabolic alterations. Treatment was tailored when culture results were available. Recommended duration of antibiotic therapy for UTI in diabetes was followed.

Follow-up

Symptomatic UTI patients were followed for 6 months with respect to the number of UTIs (urine examination or culture documented), any antibiotic treatment received for the same, and hospitalizations. At the end of follow-up, these patients again underwent urine examination, urine culture sensitivity, 24-h urinary protein estimation, FBG, PP, CBC, RFT, and HbA1c.

Statistical analysis

Quantitative variables were expressed as means ± standard deviation, whereas qualitative variables were expressed in terms of proportion. Categorical variables were compared employing Chi-square test and Fisher's exact tests, whereas continuous variables were compared using Student's *t*-test for independent observations. For paired or matched observations, McNemar's test and paired Student's *t*-test were used for categorical and continuous variables, respectively. To study the joint effects and interactions of various independent variables, binary logistic regression analysis was carried out to calculate multivariate *P* value. $P < 0.05$ was considered statistically significant. All the analyses were performed by the statistical software SPSS version 21 (IBM SPSS statistics for windows, Armonk, NY, USA: IBM Corp).

Results

Table 1 demonstrates the baseline characteristics of T2D patients with symptomatic UTI. Out of a total of 200 patients, 81% were females as compared to 19% of males. The mean age of males was higher than females ($P = 0.002$). Most of the female patients were postmenopausal (76.5%). The mean duration of diabetes was higher in females than males, 11.75 ± 6.66 and 7.59 ± 4.09 years, respectively ($P < 0.001$). With respect to diabetic microvascular complications, retinopathy and nephropathy were significantly higher in females than males with UTI ($P < 0.001$). The presence of previous UTI did influence substantially the further development of UTI in females. Obesity in females was associated with UTI ($P < 0.05$).

Table 2 shows the clinical characteristics of female and male T2D patients with symptomatic UTI. The most common UTI symptoms were fever (77.8%) and dysuria (77%). Altered sensorium and renal tenderness were predominantly found in females ($P < 0.05$). Among the type of UTI, lower UTI was present in 55.5% and pyelonephritis 44.5%, EPN in 9.5%, and bacteremia in 58.1%. EPN was present only in females ($P = 0.027$). AKI was present in 26% of symptomatic UTI patients but significantly higher in females ($P = 0.045$). Severe hyperglycemia was present 83.5%, DKA in 8%, HHS in 13%, shock in 14.5%, and MODS in 10.5%.

Table 3 shows the laboratory parameters of T2D patients with symptomatic UTI. Female patients with UTI had significantly higher mean FBG and PP than males ($P < 0.05$). HbA1c was significantly higher in females with UTI than males, 11.20 ± 2.31 and 10.40% ± 1.86%, respectively. Renal parameters were similar between females and males. Glycosuria and hematuria correlated significantly with female UTI ($P < 0.05$). Bacteriuria was seen in 68.5% of females and 71.1% of males. *E. coli* was the most common isolated organism. Cystopathy correlated with female symptomatic UTI ($P < 0.05$).

Out of 200 T2D patients with symptomatic UTI, only 169 had complete follow-up at 6 months. Out of 169 patients, 67 developed UTI on follow-up, 33 patients developed one episode, 20 patients two episodes, 10 patients three episodes, three patients four episodes, and one patient five episodes. Patients with UTI had lower mean FBG and PP at follow-up than baseline ($P < 0.05$), but HbA1c did not improve at follow-up, as shown in Table 4. Renal parameters (eGFR) improved

Table 1: Baseline characteristics of type 2 diabetes patients with symptomatic urinary tract infection

	Total	Females	Males	*P**
Number of patients	200	162 (81)	38 (19)	
Age (years)	56.32±8.12	54.53±9.88	59.89±6.98	0.002
Postmenopausal		124 (76.5)		
Marital status	190 (95)	157 (96.9)	35 (92.1)	0.175
Diabetes duration (years)		11.75±6.66	7.59±4.09	0.000
Diabetic complication				
Retinopathy	112 (56)	102 (63)	10 (26.3)	0.000
Nephropathy	107 (53.5)	97 (59.9)	10 (26.3)	0.000
Neuropathy	101 (50.5)	83 (51.2)	18 (47.4)	0.668
Treatment				
Oral drugs for diabetes	81 (40.5)	64 (39.5)	17 (44.7)	0.554
Insulin	167 (83.5)	138 (85.2)	29 (76.3)	0.185
Insulin dose units/kg	0.74±0.31	0.76±0.35	0.68±0.27	0.579
Comorbidity				
Obesity (BMI≥25 kg/m^2)	121 (60.5)	104 (64.2)	17 (44.7)	0.027
HTN	153 (76.5)	127 (78.4)	26 (68.4)	0.192
Hypothyroidism	37 (18.5)	32 (19.8)	5 (13.2)	0.346
CKD	25 (12.5)	22 (13.6)	3 (7.9)	0.425
CAD	10 (5)	8 (4.9)	2 (5.3)	1.000
History of symptomatic UTI in year before study entry	61 (30.55)	54 (33.3)	5 (13.2)	0.014

Categorical variables, *n* (%) and continuous variables (mean±SD). **P*<0.05 is considered statistically significant. HTN: Hypertension, CKD: Chronic kidney disease, CAD: Coronary artery disease, BP: Blood pressure, BMI: Body mass index, UTI: Urinary tract infection, SD: Standard deviation

Table 2: Clinical characteristics of type 2 diabetes patients with symptomatic urinary tract infection

Parameter	Total (%)	Women (%)	Men (%)	*P**	OR (95% CI)
Fever (>38.3°C)	154 (77.8)	125 (78.1)	29 (76.3)	0.809	1.10 (0.48-2.55)
Dysuria	154 (77)	123 (75.9)	31 (81.6)	0.456	0.71 (0.29-1.74)
Frequency	115 (57.5)	92 (56.8)	23 (60.6)	0.675	0.85 (0.41-1.76)
Nausea/vomiting	55 (27.5)	45 (27.8)	10 (26.3)	0.856	1.07 (0.48-2.39)
Flank pain	63 (31.5)	56 (34.6)	7 (18.4)	0.054	2.34 (0.96-5.65)
Altered sensorium	29 (14.5)	28 (17.3)	1 (2.6)	0.020	7.73 (1.01-58.72)
Hematuria	5 (2.5)	4 (2.5)	1 (2.6)	1.000	0.94 (0.10-8.62)
Renal tenderness	37 (18.5)	35 (21.6)	2 (5.3)	0.019	4.96 (1.13-21.62)
Diagnosis					
Lower UTI	111 (55.5)	92 (56.8)	19 (50)	0.448	1.31 (0.64-2.66)
Pyelonephritis (upper UTI)	89 (44.5)	70 (43.2)	19 (50)	0.448	0.76 (0.37-1.54)
EPN	19 (9.5)	19 (11.7)	0	0.027	1.26 (1.17-1.36)
Bacteremia (n=81)	47 (58.1)	38 (52.7)	9 (60)	0.647	0.76 (0.24-2.38)
AKI	52 (26)	47 (29)	5 (13.2)	0.045	2.69 (1.00-7.33)
Severe hyperglycemia	167 (83.5)	136 (83.9)	31 (81.6)	0.732	1.23 (0.40-2.89)
HHS	26 (13)	23 (14.2)	3 (7.9)	0.299	1.32 (0.58-3.49)
DKA	16 (8)	14 (8.6)	2 (5.3)	0.500	0.81 (0.39-1.64)
Shock	29 (14.5)	23 (14.2)	6 (15.8)	0.801	1.10 (0.48-2.55)
MODS	21 (10.5)	15 (9.2)	6 (15.8)	0.232	1.49 (0.72-3.05)

Categorical variables *n* (%). **P*<0.05 is considered statistically significant. EPN: Emphysematous pyelonephritis, AKI: Acute kidney injury, HHS: Hyperglycemic hyperosmolar state, DKA: Diabetic ketoacidosis, MODS: Multiorgan dysfunction syndrome

Table 3: Laboratory parameters of type 2 diabetes patients with symptomatic urinary tract infection

Parameter	Total	Women	Men	*P**
FBG (mg/dl)	251.82±94.36	263.52±102.61	209.50±55.13	0.002
Blood glucose PP	309.14±103.82	324.08±123.42	272.47±61.26	0.013
HbA1c (%)	10.90±2.01	11.20±2.31	10.40±1.86	0.049
Creatinine (mg/dl)	1.88±1.53	1.78±1.23	2.18±1.68	0.100
eGFR (ml/min/1.73 m^2)	47.56±27.65	47.53±29.36	47.76±24.21	0.965
Proteinuria	126 (63)	105 (64.8)	21 (55.25)	0.272
Leukocytosis	87 (43.5)	76 (46.9)	11 (28.9)	0.044
Urine examination				
Pyuria	187 (93.5)	153 (94.4)	34 (89.5)	0.276
Hematuria	64 (32)	58 (35.8)	6 (15.8)	0.017
Glycosuria	172 (86)	150 (92.5)	22 (57.8)	0.000
Urine culture				
Bacteriuria	138 (69)	111 (68.5)	27 (71.1)	0.761
Organism				
E. coli	110 (55)	85 (52.5)	25 (65.8)	
E. faecalis	12 (6)	11 (6.8)	1 (2.6)	
K. pneumoniae	5 (2.5)	4 (2.5)	1 (2.6)	
S. aureus	3 (1.5)	3 (1.9)	0	
E. faecalis/E. coli	1 (0.5)	1 (0.6)	0	
Candida spp.	6 (3)	6 (3.7)	0	
Yeast	1 (0.5)	1 (0.6)	0	
Ultrasonography				
Renal cyst	17 (8.5)	15 (9.3)	2 (5.3)	0.746
Renal calculi	18 (9)	16 (9.9)	2 (5.3)	0.534
Cystopathy	38 (19)	36 (22.2)	2 (5.3)	0.017

Categorical variables *n* (%) and continuous variables (mean±SD). **P*<0.05 is considered statistically significant. FBG: Fasting blood glucose, PP: Postprandial, HbA1c: Glycosylated hemoglobin, eGFR: Estimated glomerular filtration rate, SD: Standard deviation, *E. faecalis: Enterococcus faecalis, E. coli: Escherichia coli, K. pneumoniae: Klebsiella pneumoniae, S. aureus: Staphylococcus aureus*

significantly at follow-up ($P = 0.018$). *E. coli* was still the most common organism at follow-up. Recurrent UTI (67 patients) had significantly higher HbA1c at follow-up (12.56 ± 0.82%) than at baseline (11.73 ± 2.42%) ($P = 0.012$), as shown in

Table 5. Renal parameters were not significantly different at follow-up. In nonrecurrent (102 patients) UTI patients, mean FBG and PP reduced at follow-up from baseline ($P < 0.001$), but HbA1c did not improve at follow-up. Renal parameters improved significantly ($P = 0.033$) at follow-up.

Discussion

UTI frequently occurs in female diabetic patients and leads to significant morbidity and mortality. UTI in diabetes is often given less importance, more attention being paid to chronic diabetic complications. Awareness of the disease and the complexities of UTI will help to reduce morbidity and mortality. In this study, we evaluated the clinical profile, complications, and follow-up of admitted acute symptomatic UTI in patients with T2D and the effect on glycemic control and renal parameters.

Symptomatic urinary tract infection in type 2 diabetes

In our study, symptomatic UTI was more common in T2D females (81%) as has been reported in other studies.[12-14] We observed a higher risk of symptomatic UTI among postmenopausal women (76.5%), and this was also observed by Boyko *et al*.[2] The mean duration of diabetes was significantly longer in females than males in our study ($P < 0.001$). The study by Boyko *et al*.,[2] Chiţă *et al*.,[15] and Janifer *et al*.[16] revealed that diabetes of longer duration was related to substantial increases in the risks of UTI.

Retinopathy and nephropathy were significantly higher in females than males with UTI in our study, as shown in Table 1. The association between nephropathy and UTI has been studied in the literature, especially regarding the increased albumin excretion rate, with microalbuminuria or macroalbuminuria being incriminated as risk factors for the occurrence of UTI.[12] In our study, the presence of obesity and previous history of UTI did significantly influence further development of UTI in females. Al-Rubeaan *et al*.[17] also found UTI related to females and obesity. The association of obesity with symptomatic UTI could be because of coincidence, as obesity is common in women.

In our study, the most common UTI symptoms were fever (77.8%) and dysuria (77%). Altered sensorium and renal tenderness were predominantly found in females. This could be because complicated UTI (EPN) was frequently observed in females, which has a poor prognosis. EPN and AKI were associated with females' symptomatic UTI. Aswani *et al*.[18] and another study[19] also showed fever and dysuria to be common symptoms. UTI-induced AKI occurred in approximately 40% of diabetic patients in a study by Robbins and Tucker.[20] A survey in elderly patients from Greek with acute pyelonephritis found that 30.7% of patients with diabetes had bacteremia.[4] Bacteremia was present in 58.1% of symptomatic UTI patients. Kumar *et al*.[21] in their study revealed that bacteremia was present in about 44% of diabetes patients with uncomplicated pyelonephritis.

In the present study, female patients with UTI had higher mean FBG, PP, and HbA1c. Studies[15,18,22] have shown that individuals with poor glycemic control were more likely to suffer from UTI, while several studies[13,14] including a study by Geerlings *et al*.[12] in 636 women with diabetes have reported no relationship between UTI and glycemic control. Hyperglycemia itself does not predictably increase rates of bacterial multiplication as reported by Geerlings *et al*.,[23] but elevated urinary or tissue glucose levels impair neutrophil function as studied by Balasoiu *et al*.[24]

In the present study, bacteriuria was present in 69% of patients, with 68.5% in females and 71.1% in males. *E. coli* (55%) was the most commonly isolated organism in symptomatic UTI. Sharma *et al*.[25] reported prevalence of bacteriuria in

Table 4: Follow-up of type 2 diabetes patients with symptomatic urinary tract infection

Variables	UTI at baseline (n=169), n (%)	UTI at follow-up (n=169), n (%)	P*
FBG (mg/dl)	245.43±94.26	209.81±49.84	0.000
Blood glucose PP	307.36±103.36	264.07±54.62	0.000
HbA1c (%)	10.89±2.20	11.18±1.47	0.110
Uncontrolled diabetes (HbA1c≥7%)	167 (98.8)	169 (100)	-
Urea (mg/dl)	60.85±49.19	49.33±30.35	0.000
Creatinine (mg/dl)	1.85±1.40	1.67±1.26	0.013
eGFR ml/min/1.73 m^2	48.86±29.61	53.80±22.22	0.018
Proteinuria	119 (70.8)	62 (36.9)	0.000
Bacteriuria	91 (68.4)	29 (21.8)	0.000
Leukocytosis	28 (54.9)	8 (15.7)	0.000
Pyuria	158 (93.5)	32 (18.9)	0.000
Hematuria	54 (32)	19 (11.2)	0.000
Glycosuria	145 (86.3)	57 (33.9)	0.000
Organism			
E. coli	95 (56.2)	25 (14.8)	0.248
Other	21 (12.5)	8 (4.7)	

Categorical variables n (%) and continuous variables mean±SD. *P<0.05 is considered statistically significant. FBG: Fasting blood glucose, PP: Postprandial, HbA1c: Glycosylated hemoglobin, eGFR: Estimated glomerular filtration rate, UTI: Urinary tract infection, SD: Standard deviation, *E. coli: Escherichia coli*

Table 5: Follow-up of type 2 diabetes patients with symptomatic urinary tract infection on the basis of recurrent urinary tract infection

Variables	Recurrent UTI baseline (*n*=67)	Recurrent UTI follow-up (*n*=67)	*P**	Nonrecurrent UTI baseline (*n*=102)	Nonrecurrent UTI follow-up (*n*=102)	*P**
FBG (mg/dl)	260.0±97.0	244.6±47.0	0.265	235.8±91.6	186.9±36.7	0.000
Blood glucose PP	321.9±132.4	304.6±38.1	0.315	297.7±77.9	237.4±46.9	0.000
HbA1c (%)	11.73±2.42	12.56±0.82	0.012	10.34±1.85	10.27±1.03	0.729
Uncontrolled diabetes	76 (100)	76 (100)	-	91 (97.8)	93 (100)	-
Urea (mg/dl)	73.19±56.60	63.88±38.46	0.128	50.75±42.01	39.78±18.27	0.000
Creatinine (mg/dl)	2.35±1.79	2.25±1.74	0.507	1.52±0.94	1.28±0.56	0.001
eGFR ml/min/1.73 m^2	38.47±25.53	43.11±21.07	0.062	53.68±18.23	59.51±20.58	0.033
Proteinuria	55 (82.1)	41 (61.2)	0.121	64 (62.7)	21 (20.5)	0.000
Bacteriuria	45 (73.8)	25 (41)	0.000	45 (63.4)	4 (4.6)	0.000
Leukocytosis	19 (76)	6 (24)	0.000	9 (34.6)	2 (7.7)	0.039
Pyuria	65 (97)	29 (43.3)	0.000	93 (91.2)	1 (1.1)	0.000
Hematuria	24 (35.8)	13 (19.4)	0.061	30 (29.4)	6 (5.9)	0.000
Glycosuria	62 (92.5)	34 (50.7)	0.000	83 (81.4)	23 (22.5)	0.000
Organism						
E. coli	42 (55.3)	23 (30.3)	-	53 (57)	2 (2.2)	-
Other	13 (17.1)	5 (6.5)		8 (8.6)	3 (3.2)	

Categorical variables *n* (%) and continuous variables (mean±SD). *P<0.05 is considered statistically significant. FBG: Fasting blood glucose, PP: Postprandial, HbA1c: Glycosylated hemoglobin, eGFR: Estimated glomerular filtration rate, UTI: Urinary tract infection, SD: Standard deviation, E. coli: Escherichia coli

43% of patients of elderly T2D, while Kumar *et al*.[21] in their study revealed bacteriuria in about 87% of uncomplicated pyelonephritis. Another study also showed that bacteriuria was common in females.[26] *E. coli* was also the most common cause of UTI in diabetes from Western and Indian studies.[13-16,18,25] In the present study, six patients had UTI due to *Candida*, while another study[18] also reported a similar finding. The relative higher percentage of *Enterococcus faecalis* could be because the patients were hospitalized and higher rates of *Enterococcus* have been reported in hospitalized patients.[27]

Follow-up of type 2 diabetes patients with symptomatic urinary tract infection

The prevalence of recurrent UTI was 39.6%. Recurrent UTI was common in females (44.8%) compared to males (18.2%). In the study conducted by Gorter *et al*.,[28] relapses and reinfections were reported in 7.1% and 15.9% of diabetic women. In a Finnish study on women, who had *E. coli* cystitis, 44% had a recurrence within 1 year.[29]

With intensive treatment, there is an improvement in short-term glycemia (mean FBG and PP) and renal function, but long-term glycemia (HbA1c) does not improve after UTI even with intensive treatment. Recurrent UTI patients have poor glycemia, and renal function continues to remain altered even with intensive treatment, despite large number of patients had AKI. There is a limitation of studies, which have followed UTI in patients with diabetes for glycemic control and renal parameters. The study revealed that *E. coli* is not only the number one cause of UTI in women, but it also increases the likelihood of recurrence.[30] Symptomatic UTI is a consequence of or leads to uncontrolled glycemia, which in turn perpetuates UTI risk and leads to a vicious cycle.

This study needs to be considered in light of strengths and limitations. Prospective nature and adequate sample size were some of the strengths of the study. The present study had several limitations. First, it was a single-center study; second, other risk factors such as frequency of sexual intercourse and the use of condoms were not analyzed and duration of follow-up was short. Third, the detailed management of symptomatic UTI has not been discussed in this article.

Conclusion

Symptomatic UTI in T2D patients is common in postmenopausal females with longer duration of diabetes, poor glycemic control, and cystopathy and complicated by chronic diabetic complications. A significant number of patients develop recurrent UTI on follow-up. Recurrent UTI patients have poor glycemic control on follow-up, while renal parameters do not improve even with intensive treatment. Hence, it is recommended to treat diabetes and chronic diabetic complications aggressively, to prevent UTI and recurrences. Long-term prospective studies on symptomatic UTI in T2D patients are required to identify risk factors which can help pinpoint modifiable factors amenable to a disease prevention strategy and improve the overall management.

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Conflicts of interest
There are no conflicts of interest.

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