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Urinary tract infections and associated factors among patients with an enlarged prostate at a tertiary hospital, Dar es Salaam, Tanzania: a hospital-based cross-sectional study

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ABSTRACT

Objectives The objectives are to determine the prevalence of urinary tract infection (UTI) and associated factors among patients diagnosed with benign prostatic hyperplasia and prostate cancer.

Design Hospital-based cross-sectional study.

Settings Urology clinic and urology ward at Muhimbili National Hospital, which is the main tertiary hospital in Tanzania's largest city.

Participants Patients with benign prostate hyperplasia and prostate cancer presenting with genitourinary symptoms.

Main outcome measure The primary outcome was the occurrence of UTI and factors associated with UTI in patients with benign prostatic hyperplasia and prostate cancer.

Results 402 participants were enrolled, with a median age of 68 years and IQR of 61–75 years. The proportion of UTI was 46.5% (95% CI 41.56% to 51.53%). UTI was more prevalent among inpatients, patients with indwelling urinary catheters, patients with prostate size>80 cm^3 and those with residual urine volume of >100 mL. In multivariate analysis, age>60 years (adjusted OR (aOR)=2.0, 95% CI 1.13 to 3.55, p=0.018), post-void residual urine volume>100 mL (aOR 1.32, 95% CI 0.67 to 2.59 p=0.001), patient with incomplete bladder emptying (aOR=2.57, 95% CI 1.44 to 4.59, p=0.001) and prolonged catheter duration (aOR=1.24, 95% CI 1.11 to 1.38, p=0.005) were significantly associated with UTI.

Conclusion Almost half of the patients with an enlarged prostate and genitourinary symptoms had a laboratory-confirmed UTI. The risk of UTI increases with age, incomplete bladder emptying and increased duration of catheterisation. A 1-day increase in the duration of catheterisation increased the risk of UTI by 24%.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Using the Analytical Profile Index as an additional identification test increased the accuracy of identifying Gram-negative rods.
⇒ We conducted a receiver-operating characteristic curve analysis to predict the duration of the catheter use, in days, at risk of developing a urinary tract infection (UTI) in men with benign prostate hyperplasia and prostate cancer, which was not done in similar studies.
⇒ We enrolled patients with enlarged prostate and genitourinary symptoms without determining whether the genital symptoms were solely due to obstruction caused by the enlarged prostate, without microbial infection, consequently affecting the UTI detection rate.

INTRODUCTION

Urinary tract infection (UTI) in adult men is often complicated and caused by structural or functional abnormalities of the genitourinary tract. The abnormalities may be due to benign prostate hyperplasia (BPH), prostate cancer, bladder stones or catheterisation.[1] UTI related to an enlarged prostate occurs because the bladder does not empty completely, allowing urine to stagnate and creating a suitable environment for pathogens to grow.[2] The risk for UTI increases with a larger prostate size, leading to a higher post-void residual (PVR) urine volume.[3]

Urinary catheterisation is commonly used to relieve retained urine in the urinary bladder obstructed by an enlarged prostate gland.[4] Prolonged use of urinary catheters poses a major risk for UTI.[5] However, the exact duration for urinary catheters to cause UTI is unknown.[5 6] A study conducted at Bugando Medical Centre in Mwanza reported that 39% of patients had retained urinary catheters beyond the recommended time,

Table 1 Proportion of UTI among men with BPH and prostate cancer at Muhimbili National Hospital

Variable	Culture results		
	N (%)	Positive, n (%)	P value
Age (years)			
40–60	125	42 (33.6)	<0.001
>60	277	145 (52.3)	
Service unit			
IPD	175	103 (58.9)	<0.001
OPD	227	85 (37.4)	
Diagnosis (histology)			
BPH	283	127 (44.9)	0.309
Prostate cancer	119	60 (50.4)	
Urine type			
Mid-stream urine	281	102 (36.3)	<0.001
Catheterised urine (indwelling catheter)	121	85 (70.2)	
Prostate size (cm^3)			
<40	172	61 (35.5)	<0.001
40–80	77	32 (41.6)	
>80	153	94 (61.4)	
Post-void residual urine volume (mL) (n=278)			
<100	225	74 (32.9)	0.051
>100	53	25 (47.2)	
Incomplete bladder emptying			
Yes	204	113 (55.4)	<0.001
No	198	73 (36.9)	
Invasive urological instrumentation			
Yes	159	105 (66.0)	<0.001
No	243	82 (33.7)	
Recent urological surgery*			
Yes	101	53 (52.5)	0.165
No	301	134 (44.5)	
Surgical prophylaxis			
Yes	60	30 (50.0)	0.559
No	342	157 (45.9)	
Recent hospitalisation*			
Yes	107	65 (60.7)	<0.001
No	295	121 (41.0)	

*Duration for recent urological surgery and recent hospitalisation was within 30 days.
BPH, benign prostate hyperplasia; IPD, Inpatient Department; OPD, Out-patient Department; UTI, urinary tract infection.

leading to an increased risk for UTI with the duration of catheter use.[5]

The occurrence of UTI in patients with BPH and prostate cancer varies across different studies and populations.[7 8] Isolated bacteria causing UTI have been reported to show a high level of resistance to prescribed antimicrobials, thus complicating the management of UTI in this population.[9] Identifying the factors that make patients more prone to UTI and taking appropriate measures is crucial in developing effective strategies to prevent UTI in this group, and therefore improving patient lifestyle and outcomes. Therefore, our current study aims to assess the magnitude of UTI, identify the factors associated with them and determine the optimal duration for indwelling urinary catheter use with a low risk of UTI.

MATERIALS AND METHODS

Study design and setting

The study was a hospital-based cross-sectional design conducted at Muhimbili National Hospital (MNH) in Dar es Salaam. MNH, which is a referral and teaching hospital, has a 1500-bed capacity and is the largest tertiary hospital in Tanzania. It sees over 1000 outpatients per week and serves approximately seven million people in the Dar es Salaam region.

Enrolment and sample size estimation

The study involved male patients who had been clinically diagnosed with BPH or prostate cancer through digital rectal examination. We only included patients who had genitourinary symptoms within the past month and were mentally competent to give consent. Patients with a urinary catheter for more than 1 month and those with other causes of bladder outlet obstruction, such as urethral stricture, urolithiasis, bladder cancer and neurogenic causes, were excluded from the study.

The minimum sample size was 380, calculated using the Kish and Leslie formula (1965), considering the prevalence of 44.7% in Niger, in 2016. Participants were enrolled consecutively from August 2021 to January 2022 until the predetermined sample size was reached

Data collection

We used a structured questionnaire to gather information about the participants' sociodemographic and clinical details, as well as genitourinary symptoms. The questionnaire included inquiries about the participants' age and place of residence of participants, recent instrumentation (within 30 days of data collection) and duration of catheter use in days, recent urological surgeries (within 30 days of data collection) and recent use of antibiotics (within 30 days of data collection). We also obtained radiological and histopathological results from the patient's records.

Urine collection

Mid-stream urine was collected for culture from non-catheterised patients. For catheterised patients, a clump was placed above the port to allow urine to collect in the bladder, followed by disinfection of the port with 70% alcohol and iodine solution and clump release to collect urine into a sterile urine container. 10 mL of urine were

Table 2 Factors associated with UTI among patients with BPH and prostate cancer at Muhimbili National Hospital

	Univariable analysis			Multivariable analysis		
Variable	cOR	95% CI	P value	aOR	95% CI	P value
Age (years)						
>60	2.17	1.50 to 3.37	0.001	2.0	1.13 to 3.55	0.018
40–60	Ref			Ref		
Service unit						
IPD	2.33	1.56 to 3.49	<0.001	1.10	0.60 to 2.01	0.761
OPD	Ref			Ref		
Prostate size (cm^3)						
>80	3.45	2.12 to 5.96	<0.001	1.23	0.65 to 2.27	0.511
40–80	1.87	1.19 to 2.96	0.007	1.06	0.47 to 2.36	0.891
<40	Ref			Ref		
Post-void residual urine volume						
>100	1.90	1.03 to 3.50	0.039	1.32	0.67 to 2.59	0.001
<100	Ref			Ref		
Incomplete bladder emptying						
Yes	2.13	1.43 to 3.17	<0.001	2.57	1.44 to 4.59	0.001
No	Ref			Ref		
Invasive urological instrumentation						
Yes	3.65	2.39 to 5.55	<0.001	1.06	0.46 to 2.44	0.901
No	Ref			Ref		
Duration of indwelling catheter	1.22	1.11 to 1.35	<0.001	1.24	1.11 to 1.38	0.005
Recent hospitalisation*						
Yes	2.18	1.40 to 3.42	0.001	0.623	0.29 to 1.32	0.217
No	Ref			Ref		

*Duration for recent hospitalisation was within 30 days.
aOR, adjusted OR; BPH, benign prostate hyperplasia; cOR, crude OR; IPD, Inpatient Department; OPD, Out-patient Department; Ref, reference category; UTI, urinary tract infection.

collected and sent to the microbiology laboratory at MNH for processing immediately.

Bacterial isolation and identification

Urine was inoculated onto cysteine lactose electrolyte deficient agar and blood agar plates using a 1 µL loop and incubated aerobically at 37°C for 18–24 hours. Identification from culture plates with significant bacteria growth of $\geq 10^5$ (colony-forming unit/mL) based on Gram stain characteristics, colony morphology and biochemical tests as described by Mahon *et al*.[10] Gram-positive bacteria were identified by catalase, coagulase and DNase (Remel Europe, Dartford, UK), while Gram-negative bacteria were identified by oxidase, Kligler iron agar, urease, citrate and sulphur, indole and motility (Oxoid, Hampshire, UK). Analytical Profile Index (API-20E) (Biomerieux, France) was used to identify Gram-negative rods further. *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853 were used for quality control of culture media and biochemical tests.

Statistical analysis

Data analysis was performed using Statistical Package for the Social Sciences V.27. We used frequencies and percentages for categorical variables and median (IQR) for continuous variables. The χ^2 test was used to assess the difference in categorical variables. We used a receiver operating characteristics (ROC) to determine the appropriate duration of urinary catheter stay to prevent UTI. A univariate regression model was used to identify the factors associated with UTI, and factors with a p value≤0.2 in a univariate model were considered for the multivariate logistic regression analysis. A p value of <0.05 was considered to be statistically significant.

Reporting guideline

This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cross-sectional studies, which provide a checklist for reporting observational studies. The checklist comprises key components that should be included in the report, including study design, sampling procedure,

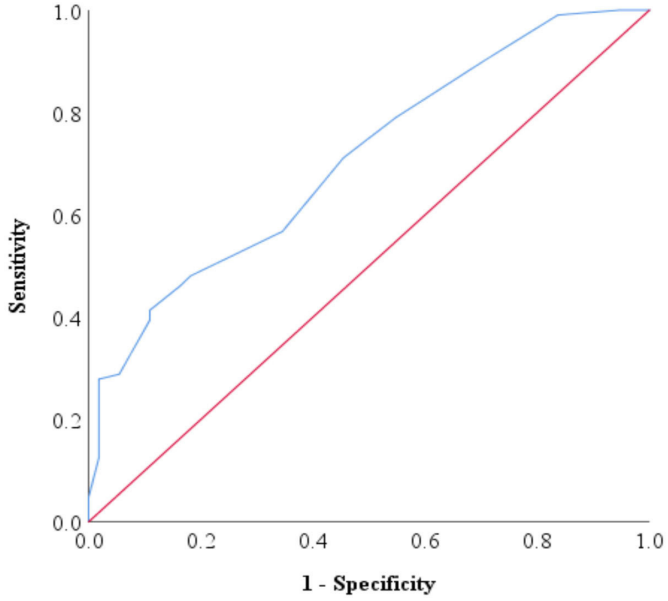

Figure 1 Receiver-operating characteristics curve for inserted urinary catheter-associated urinary tract infection based on the number of catheter days for men with benign prostate hyperplasia and prostate cancer at Muhimbili National Hospital.

data collection and statistical analysis. The authors have attentively reviewed the checklist to make sure that suitable items have been included. The authors used a structured data collection tool to collect information from all study participants and used suitable statistical methods to analyse data and formulate conclusions.

Patient and public involvement

Patients and the public were not involved in this research design, conduct, reporting or dissemination plans.

RESULTS

Description of study participants

In this study, a total of 402 participants were enrolled. The median age of the participants was 68, and the IQR was 61 and 75 years. The majority of the participants were from the outpatient (227/402, 56.2%). BPH was the most common prostatic disease, affecting 70.4% of the participants. The median prostate size measured using ultrasonography was 43 cm^3 (IQR was 24.0–74.8). Most participants (46.5%) had a prostate volume of 40 cm^3, while 19.1% had a PVR urine volume of ≥100 mL. Among the participants, 40% (161/402) had undergone invasive urological instrumentation, and the urinary catheter was the most invasive instrument used 155/161 (96.3%) while cystoscopy accounted for 3.7%.

The proportion of UTI among study participants

The overall proportion of laboratory-confirmed UTI was 46.5% (95% CI 41.56% to 51.53%). UTI was found more in inpatients (103, 58.3%) than in outpatients (85, 37.4%), p<0.001. UTI was significantly higher among catheterised patients (85, 70.2%) than non-catheterised patients (102, 36.3%), p<0.001. Patients who had prostate size more than 80 cm^3 had a significantly higher proportion of UTI (55, 65.5%) than those with prostate size less than 40 cm^3 (66, 35.5%), p=0.001. Those with a PVR urine volume of more than 100 mL had a higher proportion of UTI (25, 47.2%) than those with a urine volume of less than 100 mL (74, 32.9%), p=0.051. Patients who had undergone instrumentation had a significantly higher proportion of UTI (104, 65.4%) than those who did not undergo invasive urological instrumentation (82, 33.9%), p=0.001. In comparison, there was no significant difference in UTI among patients with BPH 127 (44.9%) and prostate cancer (60, 50.4%), p=0.309 and among patients who had undergone recent urological surgery (53, 52.5%) compared with those who did not undergo any urological surgery (134, 44.5%), p=0.165 (table 1).

Factors associated with UTI

In univariate analysis, patients aged>60 years had two times the odds of having UTI compared with those aged<60 years (crude OR (cOR)=2.17, 95% CI 1.50 to 3.37, p<0.001). Inpatients were observed to have two times the odds of having UTI compared with outpatients (cOR=2.33, 95% CI 1.56 to 3.49, p<0.001). Patients with incomplete bladder emptying (cOR=2.13, 95% CI 1.43 to 3.17, p<0.001) and those with recent hospitalisation (cOR=2.18, 95% CI 1.40 to 3.42, p<0.001) were also found to have approximately two times the odds of having UTI. Moreover, patients with a prostate size>80 cm^3 (cOR=3.45, 95% CI 2.12 to 5.96, p<0.001) and those who had undergone invasive urological instrumentation (cOR=3.65, 95% CI 2.39 to 5.55, p<0.001) were observed to have approximately three times the odds of having a UTI.

In multivariate analysis, patients aged>60 years had two times the odds of having a UTI compared with those aged<60 years (aOR=2.0, 95% CI 1.13 to 3.55, p=0.018). Patients with PVR urine volume of more than 100 mL had a higher risk of having UTI than those with PVR urine volume of <100 mL (aOR=1.32, 95% CI 0.67 to 2.59, p=0.001). Patients with incomplete bladder emptying had two times the odds of having a UTI compared with those with complete bladder emptying (aOR=2.57, 95% CI 1.44 to 4.59, p=0.001). Additionally, the odds of UTI increased by 24% for each 1-day increase in the duration of catheter use (aOR=1.24, 95% CI 1.11 to 1.38, p=0.005) (table 2).

Risk for UTI in indwelling catheter

An ROC curve illustrating the development of UTIs based on the duration of a urinary catheter is depicted in figure 1. The area under the curve was 0.709 (95% CI, 0.67 to 0.79, p<0.001), with the optimal cut-off value being 7 days. Table 3 shows data on the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for UTI at various cut-off values. At the optimal cut-off value of 7 days, the sensitivity, specificity, PPV and NPV were 71.15%, 54.5%, 74.5% and 50%, respectively (table 3).

Table 3 Sensitivity, specificity, positive predictive value and negative predictive value for catheter-associated urinary tract infection at different cut-off values of catheter days

Cut-off values of catheter days	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden's index	AUC	Metric score
2	100	0	65.41	–	0.00000	0.709	1.00
3	100	5.45	66.67	100	0.05455	0.709	1.05
4	99.04	16.36	69.13	90	0.15402	0.709	1.15
5	90.38	29.09	70.68	61.54	0.19476	0.709	1.19
6	78.85	45.45	73.21	53.19	0.24301	0.709	1.24
7	71.15	54.55	74.75	50	0.25699	0.709	1.26
8	56.73	65.45	75.64	44.44	0.22185	0.709	1.22
9	48.08	81.82	83.33	45.45	0.29895	0.709	1.30
10	46.15	83.64	84.21	45.1	0.29790	0.709	1.30
11	41.35	89.09	87.76	44.55	0.30437	0.709	1.30
12	39.42	89.09	87.23	43.75	0.28514	0.709	1.29
14	28.85	94.55	90.91	41.27	0.23392	0.709	1.23
15	27.88	98.18	96.67	41.86	0.26066	0.709	1.26
16	22.12	98.18	95.83	40	0.20297	0.709	1.20
17	16.35	98.18	94.44	38.3	0.14528	0.709	1.15
18	12.5	98.18	92.86	37.24	0.10682	0.709	1.11
20	4.81	100	100	35.71	0.04808	0.709	1.05
21	3.85	100	100	35.48	0.03846	0.709	1.04
22	0.96	100	100		0.00962	0.709	1.01

AUC, area under the curve; NPV, negative predictive value; PPV, positive predictive value.

DISCUSSION

This study found that out of 100 patients with an enlarged prostate and urinary symptoms, 46 had a laboratory-confirmed UTI. Patients over 60 years old and those with incomplete bladder emptying were found to be at a higher risk of developing UTI. This study also found that the longer the urinary catheter was in place, the greater the risk of developing a UTI, with a 24% increase in risk for each day the catheter was used. Incomplete bladder emptying can lead to bacterial growth, increasing the likelihood of developing a UTI. For these patients, corrective measures such as surgery may be surgery may be necessary. While catheterisation can help with incomplete bladder emptying, the findings suggest that it should not be prolonged as the risk of UTI increases with longer catheter use.

The proportion of UTI in patients with an enlarged prostate was consistent with a report by Agbugui *et al*, which found a 44.7% UTI proportion.[3 9] However, Ghana reported a higher proportion of UTI (76.6%) among male patients with BPH having urethral catheters.[11] Other studies in Austria, Saudi Arabia and Spain reported lower UTI proportions at 13.6%, 15% and 20.6%, respectively.[12–14] The differences in proportions of UTI may be due to differences in geographical location, climatic conditions, study designs and the population studied. The high proportion of UTI in our study may be attributed to instrumentation procedures, which are a risk factor for UTI. As the prostate enlarges due to physiological changes, it obstructs urine outflow from the bladder through the urethra, creating an environment for bacteria to grow and cause infected urine, leading to UTI. Frequent hospital admissions expose these patients to colonisation and infection with multidrug resistant bacteria, which may cause difficulty in treating UTIs in these patients.[4 15 16]

According to this study, there was a significant association between UTIs and the age of patients. Patients over 60 years had a higher likelihood of infection as compared with those who were 60 years or younger. Other studies have shown similar results, linking the risk of UTI with advanced age.[1 13] Oshodi *et al* reported an increase in the proportion of UTIs with age in their study, with the highest proportion being 70.6% among patients aged 80 years and older.[17] The increase in UTI with age may be due to weakened immune systems and the presence of comorbidities in older patients. Additionally, in advanced age, there is a decrease in the concentration of zinc in the prostate due to impaired zinc uptake by body cells.[18] Zinc has been found to have antibacterial properties, which can help prevent infections related to the prostate gland and UTIs among men.[19]

Incomplete emptying of the urinary bladder, leading to urine retention due to obstruction, has been significantly

associated with UTI in this study. This is consistent with previous findings reported by Hyens that urine stasis is a risk factor for developing UTI.[20] Urine retention in these patients may be worsened by factors such as enlargement of the prostate gland, cancers metastasising to the prostate gland and urethral stricture as a result of urethral trauma due to instrumentation, and advanced age, which may lead to degeneration of the brain, affecting bladder innervation and consequently, bladder emptying.[4]

In our study, a PVR>100 mL was significantly associated with UTI among these patients. Incomplete bladder emptying also results in PVR urine volume, which can harbour bacteria and predispose to UTI.[20] Additionally, other studies reported that UTI was prevalent in patients with significantly high mean PVR; however, no specific cut-off value was determined to predict positive urine culture.[3 21] Another study reported similar findings where men without symptoms but with a PVR of 180 mL were at high risk for UTI.[3]

Several studies have shown that as the prostate size increases, there is a correlation with a larger PVR, which can potentially lead to an increased risk of UTI.[12 22 23] A recent study by Righetto *et al* showed that patients with renal transplants and moderate lower urinary tract symptoms benefit from urodynamic evaluation and early trans-urethral resection of the prostate, whereby early surgical resolution of the prostate obstruction can lead to a reduced rate of UTI.[24] However, in our study, we found that prostate size was not associated with UTI. Similar findings have been reported in other studies on UTI among patients with BPH and prostate cancer, whereby prostate size was not an independent predictor of UTI.[7 9] These findings may be attributed to factors such as settings and practices including the use of antimicrobial prophylaxis in our patients to prevent UTIs.

Catheterisation is usually performed to drain urine due to retention in patients with enlarged prostates, and bladder irrigation following surgery.[4] However, our current study has shown that prolonged catheterisation beyond 7 days increases the risk of developing UTI. Several studies have also reported that the risk of UTI increases with longer catheterisation periods.[5 25] The WHO guideline recommends 7–10 days of urinary catheterisation after urinary surgical repair in short-term catheterisation.[26] The Health Infection Control Practices Advisory Committee guideline by the Centre for Disease Control does not recommend routine changing of indwelling catheters or drainage bags at fixed intervals for catheter change.[27 28] Nevertheless, since the medical practices and patient characteristics have evolved, our study suggests 7–10 days of urinary catheterisation among patients with BPH and prostate cancer to prevent UTI. It is important to note that multi-centre studies involving larger populations should be conducted to provide more comprehensive findings. This will be crucial in establishing evidence-based guidelines to determine the appropriate duration of catheterisation among this patient population. A recent study showed that in kidney-transplanted patients with lower urinary tract symptoms, early removal of the bladder catheter can lead to a reduced rate of infection and possible impairment of the transplanted kidney.[24]

One of the strengths of our study is that it includes the duration of the catheterisation in days at risk of UTI for men with BPH and prostate cancer, which was not addressed in previous studies. However, we faced challenges in determining whether genitourinary symptoms in patients with BPH and prostate cancer were solely due to an enlarged prostate causing obstruction, without any microbial infection, and this may have impacted the detection rate of UTIs.

Conclusion

Our study shows, at the multivariate analysis, a positive correlation between advanced patients' age, PVR>100 mL, incomplete bladder emptying, days of catheterisation higher than 7 days and UTI among patients with prostate enlargement and genitourinary symptoms. Intervention to resolve urinary obstruction, such as prostate surgery should not be delayed in these patients, to achieve prompt catheter removal and prevention of clinically significant UTIs.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval The ethical approval was obtained from the Senate Research and Publications Committee of the Muhimbili University of Health and Allied Sciences

(reference number DA.282/298/01.C/). Participants were requested to sign informed consent before enrolment in the study.

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Data availability statement Data are available on reasonable request. All data relevant to the study are included in the article or uploaded as online supplemental information.

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