Characteristics of Bacterial Colonization and Urinary Tract Infection after Indwelling of Double-J ureteral Stent and Percutaneous Nephrostomy Tube

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Abstract

Introduction: Infections associated with catheter in the upper urinary tract (CUUT), which include the double-J stent and the percutaneous nephrostomy (PCN) tube, get particularly infected in patients with specific risk factors for developing an infection. **Methods:** A retrospective observational study was carried out by compiling data from the hospital information system of a tertiary care center from 2019 to 2021 to evaluate infections in patients with catheter in the upper urinary tract. **Result:** A total of 200 pus samples of double-J stent (96 pus samples) and PCN tube (104 pus samples) were included in our study. Among patients with nephrostomy tube, the most frequently isolated microorganisms were *Escherichia coli*, followed by *Pseudomonas* spp. In those with a double-J stent, *Pseudomonas aeruginosa,* followed by *E. coli* were the most commonly isolated microorganisms. We found 55.72% of cases of *Enterobacteriaceae*-producing carbapenemases in patients with a percutaneous catheter. 66.07% of *Enterobacteriaceae* in patients with double-J and nephrostomy stents are extended-spectrum beta-lactamase-producing bacteria. The percentage of cultures with multiple-drug resistance (MDR) microorganisms was 38.54% in patients with double-J stents and 37.75% in nephrostomy tubes. The presence of prior urinary tract infection ($P = 0.010$), presence of urinary catheter before admission ($P = 0.005$), increased time with single urinary catheter *in-situ* ($P < 0.001$), and increased length of hospital stay ($P = 0.036$) were risk factors for isolation of MDR microorganisms. **Conclusion:** *Pseudomonas* spp. and *Pseudomonas aeruginosa* are commonly infecting both the CUUT. *E. coli* infections are more commonly infecting the nephrostomy tubes. MDR microorganisms are frequent, mainly in patients with prior urinary tract infection, presence of urinary catheter before admission, and prolonged use of a single catheter.

Keywords: Bacteria, colonization, double-j stent, nephrostomy tube, urinary tract infection

Introduction

The derivation of the upper urinary tract through a nephrostomy or double-J stent is performed for the management of obstructive uropathy.[1,2] The placement of self-retaining double-J stents has become accepted in a wide range of applications, such as relief of obstruction, prevention of stricture formation, treatment of urinary tract leaks, and facilitation of fragment clearance after extracorporeal shock wave lithotripsy. The advent of extracorporeal shock wave lithotripsy and a more rapid increase in endourologic techniques have dramatically increased the indications for indwelling ureteral stents.[3-7] With regard to indications for placement, the percutaneous nephrostomy (PCN) has evolved since its inception from an exclusively inpatient procedure to an outpatient procedure and from a predominantly temporary method for achieving drainage to a permanent fixture, especially as a palliative care option in patients with obstructive malignancy along the course of the renal drainage system.[8-10] Catheters for the upper urinary tract are simple to place and are secure devices, but they are not free of complications, and urinary infections are among the most prevalent and potentially serious.[11-13]

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It is usually assumed that double-J stent-associated infection is rare and asymptomatic, although it may be associated with significant morbidity, fever, acute pyelonephritis, bacteremia, vesicoureteral reflux, chronic renal failure, and even death.[14-16] Health-care providers diagnose infectious complications associated with PCN and offer treatment in an era of evidence-based medicine while using clinical acumen. We reviewed the literature to address this question because the Indian Direct Selling Association guidelines for prevention, diagnosis, and treatment of catheter-associated urinary tract infection categorically exclude the percutaneous nephrostomy catheter PCNC and do not address diagnostic or treatment approaches for infections associated with nephrostomy catheters.[17] Infections related to catheters in the upper urinary tract require specific management due to a high resistance rate. Therefore, the isolation of multiple-drug resistance (MDR) microorganisms is more common, including multi-resistant *Pseudomonas*, extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae* or those resistant to carbapenemases, *Enterococcus* resistant to vancomycin, and *Methicillin-Resistant Staphylococcus aureus (MRSA)*.[18]

Our purpose was to analyze the microorganisms patterns in infections associated with indwelling double-J stents and/or PCN tubes. We also reviewed multidrug resistance in our environment while paying particular attention to MDR microorganisms and its risk factors.

Methods

We performed a retrospective observational study from November 2019 to September 2021 to evaluate infections in patients with catheters in the upper urinary tract in the Bacteriology section at a Tertiary care center in Northern India.

We included all patients with nephrostomy catheter and double-J stent with a clinical diagnosis of stent or catheter-related infection. An infection was defined by a fever or symptoms and signs of urosepsis. We differentiated between patients who seemed to have acquired the urinary tract infection before admission (community-acquired infections) and hospitalized patients with infections that developed the infection nosocomially, by closely monitoring the period of hospitalization.

In all cases, urine culture was performed before administration, changing or removal of double-J stent and/or PCN tubes. In patients with a nephrostomy tube, the sample for microscopy and culture was collected by aspirating with a syringe after disinfecting the site of the tube where the sterile needle is inserted; the needle tip should also be disinfected before aspiration. For the correct interpretation of the microbiological results in the department of microbiology, only specifically labeled samples of the double-J stent and PCN were accepted as samples collected from a catheter in the upper urinary tract (CUUT).

In this study, we have observed the demographic characteristics, including age, gender, and comorbidities, such as diabetes, hypertension, cardiac and liver disease, immunosuppression, and the American Society of Anesthesiologists' physical status score.[19,20] Immunosuppression was defined as patients receiving treatment with immunosuppressant drugs, hematological malignancies, transplant recipients, and patients suffering from uncontrolled diabetes. We have also observed the cause of catheter placement among lithiasis, tumor, and other causes of urinary tract obstruction.

Microbiological characteristics and drug resistance patterns were analyzed for all the samples included in the study. Bacterial isolates were identified by routine morphological methods. Antibiotic sensitivity was detected by the Kirby–Bauer disc-diffusion method as well as the automated Vitek method (Biomerieux, France). We also demonstrated the risk factors for isolation of MDR microorganisms, among which are *Pseudomonas* resistant to at least three antibiotic groups, carbapenemases-resistant and ESBL-producing *Enterobacteriaceae*, *Enterococcus* resistant to vancomycin, and *MRSA*.[21,22]

Matrix-assisted laser desorption ionization-time-of-flight (MALDI-TOF) was used for species identification of selected isolates of *Pseudomonas* species and other nonfermenters. The *Pseudomonas* species isolate for analysis by MALDI-TOF-mass spectrometry (MALDI-TOF-MS) was prepared by mixing or coating with a solution of an energy-absorbent, organic compound called matrix. When the matrix crystallizes has dried, the isolate entrapped within the matrix also co-crystallizes. The isolate within the matrix ionizes in an automated mode with a laser beam. Desorption and ionization with the laser beam generate singly protonated ions from analytes in the isolate. The protonated ions were then accelerated at a fixed potential, where these separate from each other on the basis of their mass-to-charge ratio (m/z). The charged analytes were then detected and measured using different types of mass analyzers such as quadrupole mass analyzers, ion trap analyzers, and time-of-flight (TOF) analyzers. For microbiological applications, mainly TOF mass analyzers were used. During MALDI-TOF analysis, the m/z ratio of an ion is measured by determining the time required for it to travel the length of the flight tube. A few TOF analyzers incorporate an ion mirror at the rear end of the flight tube, which serves to reflect back ions through the flight tube to a detector. Thus, the ion mirror not only increases the length of the flight tube but it also corrects small differences in energy among ions.[23]

The statistical analysis for our study was performed by observing frequencies. Quantitative variables were expressed as mean and standard deviation. In the analysis of risk factors for MDR, the comparison between groups for categorical variables was estimated using Chi-square tests. The results were presented as 95% confidence interval. Statistical analysis was performed using the software program IBM SPSS

Statistics version 20.0 (SPSS Inc., Armonk, NY, USA), with $P < 0.05$ considered statistically significant.

Results

The study includes 200 patients with CUUT and infection. One hundred and four patients in the study had only PCN tube and 96 patients had only double-J stent. Ninety-six patients had double-J stent (13 with community-acquired infection and 40 developed the infection during hospitalization) and 104 had a PCN tube (15 with community-acquired and 43 with hospital-acquired infection). Catheter insertion was related to urolithiasis in 57.29% of cases with a double-J stent and the percentage marginally decreased to 49.03% in those with PCN tube, respectively. The reason for urinary diversion in patients with double-J stent and nephrostomy, was due to a tumor, in 22.91% and 25.96%, respectively. Among those with a double-J stent, 30.20% had an infection in the previous months, and 30.7% of those with PCN tube. Table 1 shows the descriptive characteristics.

Out of the total cases enrolled in our study, 93 (46.5%) cases did not develop any infection. In patients with a double-J stent, the microorganism most frequently isolated was *Pseudomonas aeruginosa* (21.0%), followed by *Escherichia coli* (17%) and *Pseudomonas* spp. (16%). According to the origin of the infection, *E. coli* was isolated in 39.28% of positive cultures with community-acquired infection, in comparison with 16.86% for *E. coli* and *Enterococcus faecalis* in hospital-acquired infections. During hospitalization, the patients developed an infection with *Pseudomonas* spp., and *Pseudomonas aeruginosa* in 36.14%, in comparison with 7.14% in community-acquired infections. The most commonly isolated *Pseudomonas* species were *Pseudomonas putida* and *Pseudomonas stutzeri*, as identified by MALDI-TOF-MS. *Candida* spp. was isolated in 2% and 8.77% for double-J stent and PCN tube, respectively [Figure 1]. For those with a nephrostomy tube, the most frequently isolated microorganism was *E. coli* (24.56%), followed by *Pseudomonas* spp. (14.03%) and *Klebsiella pneumoniae* (14.03%). As all the isolates of *Pseudomonas* species were not subjected to MALDI-TOF-MS, the exact percentage of the commonly acquired species could not be obtained. In patients with community-acquired infection, *E. coli* (30.76%), *Klebsiella* spp. (15.38%), and *Proteus mirabilis* (15.38%) were the most common bacteria. *E. coli* was isolated in 30.76% and 17.72% in community- and nosocomially acquired infections, respectively [Figure 1]. The percentage of patients with sterile cultures was 7.69% in community-acquired and 5.06% in nosocomially acquired infections. *Pseudomonas aeruginosa* was isolated in 3.84% and 18.98% of community- and nosocomially acquired infections, respectively. *Enterococcus* spp. represented 6.33% of microorganisms isolated in hospital-acquired infections [Figure 1].

Multidrug-resistant *Enterobacteriaceae* in this study are 37, of which 35.13% showed resistance to third-generation

Table 1: Descriptive analysis of demographic characteristics and risk factors in patients with a catheter in the upper urinary tract (*n*=200)

Demographic characteristics and risk factors	Double-J Stent (*n*=96), *n* (%)	Nephrostomy (*n*=104), *n* (%)	*P*
Source of infection			
Community-acquired	13 (13.54)	15 (14.42)	0.858
Nosocomially acquired	40 (41.66)	43 (41.34)	0.963
Cause for placement of the CUUT			
Lithiasis	55 (57.29)	51 (49.03)	0.243
Tumor/other cause	41 (42.71)	27 (25.96)	0.617
Demographics			
Age (years), mean (SD)	40.49 (16.43)	41.73 (19.49)	0.628
Gender (male/female)	68.75/31.25	64.42/35.58	0.517
ASA score			
ASA I-II	53 (55.20)	52 (49.05)	0.599
ASA III-IV	43 (44.80)	52 (49.05)	
Comorbidities			
Hypertension	47 (48.95)	49 (46.22)	0.794
Diabetes mellitus	25 (26.04)	29 (27.35)	0.769
Heart disease	18 (18.75)	21 (19.81)	0.797
Liver disease	2 (2.08)	4 (3.77)	0.465
Immunosupression	15 (15.625)	18 (17.3)	0.749
Urology history			
Prior urinary infection	29 (30.20)	32 (30.18)	0.931
Urinary catheter before admission	51 (53.12)	46 (43.39)	0.209
Time with the catheter (days), mean (SD)	67.60 (25.12)	64.46 (22.82)	0.355
Hospitalization period (days), mean (SD)	12.65 (6.79)	12.01 (6.56)	0.498

$P<0.05$ is significant. CUUT: Catheter in the upper urinary tract, ASA: American Society of Anesthesiologists [20], SD: Standard deviation

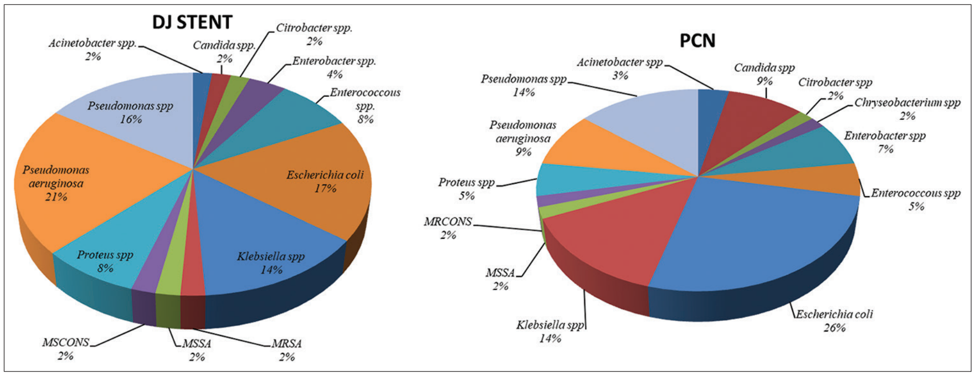

Figure 1: Microorganisms isolated from patients with double-j stent and nephrostomy tube ($N = 107$). PCN: Percutaneous nephrostomy

cephalosporin in those with a double-J stent, 63.15% with a nephrostomy tube. Among *Enterobacteriaceae*, *E. coli* showed higher rates of resistance: 13.51% were ESBL-producing *E. coli* in patients with double-J, 29.72% with a nephrostomy tube. ESBL-producing *Klebsiella* spp. were found in 10.81% and 21.62% of patients with double-J and nephrostomy, respectively. Carbapenem-resistant organisms isolated from the study are 55 (Carbapenem-resistant organisms isolated from DJ stent are 26 and those isolated from nephrostomy tube are 29), of which Carbapenem-resistant *Pseudomonas aeruginosa* isolated from DJ stent is 26.92% and 10.34% for the nephrostomy tube. In addition, *Pseudomonas aeruginosa* showed resistance to piperacillin-tazobactam in 69.23% and 15.38% in patients with double-J and nephrostomy, respectively. A high resistance rate to quinolones was observed, in patients with isolation of *E. coli* from double-J stents, with 88.89% (8 out of 9). Cultures where *Pseudomonas aeruginosa* were isolated showed a resistance rate to aminoglycosides up to 70%, while in the case of *E. coli* and *Klebsiella*, the resistance rate was around 44%. Finally, vancomycin is effective in the treatment of *Enterococcus* spp.

The percentage of cultures with MDR microorganisms was 38.54% in patients with double-J stents and 36.53% in nephrostomy tubes. The isolation of MDR organisms from the community and nosocomially acquired infections is statistically significant ($P < 0.05$). Table 2 demonstrates that there is also a statistical significance between the existence of prior urinary tract infection within 1 month of CUUT infection, dependence on urinary catheter before admission for DJ stent and/or nephrostomy tube placement, increased time with single urinary catheter *in-situ* and the number of days spent in the hospital to diagnose the cause of isolation of MDR microorganisms from the double-J stent and nephrostomy tubes.

Discussion

CUUT is used to manage urinary obstructions and to facilitate urinary drainage after surgery in the upper urinary tract. Therefore, complications related to different types of catheter-associated upper urinary tract are becoming increasingly important.[24,25] Infectious complications are the most frequent as CUUT may be associated with significant morbidity and even death.[26] Very few articles describe the infectious complications and microbiological profiles related to CUUT. A distinguishing point in comparison of a CUUT and of a urinary catheter in the lower urinary tract is the difference in the resistance pattern and also the difference in microbial flora in both the types of urinary catheterization. As seen from our data, *Pseudomonas aeruginosa* is the most commonly isolated microorganism in patients with a double-J stent, followed by *E. coli* and *Pseudomonas* spp., which mostly consists of *Pseudomonas stutzeri* and *Pseudomonas putida* which are isolated more commonly in our laboratory. These data are in concordance with other studies, which showed that *Pseudomonas*, *Enterococcus*, and *Candida albicans* are often found in patients with CUUT.[26-30] *MRSA* was found in 2% of positive cultures. The prevalence of *S. aureus* was below those found in similar series, above 10%.[13] The use of a sterile technique during the collection of samples from an individual with a double-J stent *in situ* or with a PCN tube has led to decreased isolation of *S. aureus* from these samples. In an article by Bonkat *et al*.,[31] patients with a suprapubic catheterization also showed that *Enterobacteriaceae* and *Enterococcus* are the most common microorganisms. In our study, *S. aureus* and *Coagulase-Negative Staphylococcus* spp. are isolated in 4% and 2% of cultures, respectively. Therefore, there is increased isolation of microorganisms other than *E. coli*, *Pseudomonas* being the most common isolate from patients who had undergone double-J stenting and PCN. Finally, *C. albicans* is isolated in 8.77% in patients with PCN tube and/or in 2% of patients who had undergone double-J stenting. The highest percentage of *C. albicans* was observed in patients with PCN, 8.77%. Apart from the specific microbiological profile found in patients with CUUT. In concordance with a study by Vargas-Cruz *et al*.,[32] the highest susceptibility data are observed in patients with PCN, especially when *E. coli* is isolated, 48% of *Enterobacteriaceae* in patients with double-J and nephrostomy stents are ESBL-producing bacteria.

MDR microorganism isolation is a significant concern in patients with CUUT. It accounts for 70% of the microorganisms isolated from positive cultures. In our study, we found 62.06% of cases of *Enterobacteriaceae*-producing carbapenemases in

Table 2: Risk factors for isolation of multiple-drug resistance microorganisms in patients with a catheter in the upper urinary tract (n=75)

Demographic characters and risk factors	Incidence of MDR microorganisms (n=75/107; 70.09%), n (%)	P	95% CI
Source of infection			
Community-acquired	16 (21.33)	0.021*	0.010-0.060
Nosocomially acquired	59 (78.76)	<0.001*	0.000-0.015
Cause for placement of the CUUT			
Lithiasis	35 (46.67)	0.165	0.154-0.266
Tumor/other cause	40 (53.33)	0.899	0.988-1.014
Demographics			
Age (years), mean (SD)	38.95 (17.16)	0.250	0.695-0.815
Gender (male/female)	66.67/33.33	0.969	0.986-1.023
ASA score			
ASA I-II	35 (46.67)	0.584	0.532-0.668
ASA III-IV	40 (53.33)		
Comorbidities			
Hypertension	34 (45.33)	0.559	0.594-0.726
Diabetes mellitus	20 (26.67)	0.934	0.99-1.33
Heart disease	14 (18.67)	0.818	0.818-0.912
Liver disease	3 (4.00)	0.521	0.584-0.716
Immunosupression	17 (22.67)	0.069	0.050-0.130
Urology history			
Prior urinary infection	31 (41.33)	0.010*	0.000-0.024
Urinary catheter before admission	46 (61.33)	0.005*	0.000-0.015
Time with the catheter (days), mean (SD)	54.25 (19.46)	<0.001*	0.000-0.023
Hospitalization period (days), mean (SD)	11.24 (6.47)	0.036*	0.114-0.216

*P<0.05 is significant. MDR microorganisms include extended spectrum beta - Lactamase-producing *enterobacteriacae*, carbapenemase-producing microorganism, *Pseudomonas* resistant to at least 3 group of antibiotics, Methicillin-resistant *Staphylococcous* and Vancomycin-resistant *Enterococcous* species. CUUT: Catheter in the upper urinary tract, ASA: American Society of Anesthesiologists, SD: Standard deviation, MDR: Multiple-drug resistance, CI: Confidence interval

patients with a percutaneous catheter. Thirty-eight (36.53%) pus samples from PCN were multidrug resistant. Out of the 38 samples that had isolated MDR microorganisms, 39.47% *Enterobacteriaceae* microorganisms isolated had prior urinary tract infections. Therefore, it is essential to review previous cultures when selecting an empirical treatment. The selection of antibiotic management should be based on the microbiological characteristics and antibiotic resistance of the area to improve the adequacy of antibiotic treatment.[33] According to our data, we recommend the need to adhere to the sensitivity pattern of the microorganisms as it can help in preventing the multidrug resistance in the isolates and starting empirical antibiotics after sending a single aspirate from the nephrostomy tube and double-J stent for identifying the microbiological flora and specific antimicrobial sensitivity. The risk factors for the isolation of MDR microorganisms have been evaluated in our study. According to our data, increase in the time with catheter insertion, the presence of urinary catheter before admission, and the presence of urinary tract infection on admission were statistically significant with the risk of isolation of multidrug-resistant microorganisms from the double-J stent and PCN aspirates. However, deranged blood sugar levels did not predispose to cause more infections. In our study, *Pseudomonas* and *E. coli* are the more frequently isolated nosocomially acquired microorganisms. Our study has several limitations. First, it was a retrospective study conducted in a single center, so the patient specifics had to be obtained from the hospital information system. Second, the incidence of community- and hospital-acquired infections could not be calculated because we do not have an accurate record of all patients with CUUT.

Conclusion

Infections related to CUUT showed a specific microorganism pattern. The infections related to PCN and double-J stent are mostly caused by microorganisms such as *E. coli*, *Pseudomonas*, *K. pneumonia,* and *Enterococcus* spp., when samples were collected by maintaining all aseptic precautions. MDR microorganisms are frequently isolated from these samples and their incidence should be curbed by adhering to specific antibiotic sensitivity patterns to prevent further development of resistance. They also require stringent hospital infection control practices to cease the spread of nosocomial spread of infection.

Research quality and ethics statement

The study was approved by the institute ethics committee (IEC-IMP-2021-188). The authors followed applicable EQUATOR Network (http://www.equator-network.org/) guidelines during the conduct of this research project.

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Conflicts of interest

There are no conflicts of interest.

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