Diagnostic Study

ANNALS OF MEDICINE & SURGERY

OPEN

Factors influencing bacterial colonization of double J ureteral stents: a prospective study

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Background: To investigate the microorganisms responsible for double J stent (DJS) colonization, bacteriuria, and the drug susceptibility of the isolates. We also tried to determine factors associated with stent colonization, such as indwelling time, sex, age, and comorbidities.

Materials and methods: This study is a prospective analysis of patients following DJS ablation. A total of 155 patients from our institution were enrolled in this study between January 2023 and May 2023. Bladder urine was collected in a sterile container prior to stent removal for bacteriological exam. The removed stents were divided into three parts: top (Renal), middle (Ureteral), and bottom (Bladder); 3 cm pieces from each part were taken and placed in a sterile test tube for bacteriological investigation.

Results: The mean age of patients with positive stent culture was 61.17 ± 12.82 versus 55.94 ± 10.32 when stent culture is negative, which is statistically significant $P = 0.016$. Diabetes and bacteriuria are both correlated with DJS contamination with $P < 0.001$ in the two cases. The mean duration of the use of DJS in patients with colonized stent culture is 6.45 ± 2.98 months versus 4.06 ± 2.20 months for the other patients; the difference is statistically significant $P < 0.001$. The most commonly isolated pathogens on stents were Gram-negative bacilli (53.2%), dominated by *Enterobacteriaceae* in 19 cases (55.2%).

Conclusion: Indwelling time is the only unanimous factor of stent colonization in literature, so we recommend using DJS only if necessary and to remove it as soon as possible.

Keywords: bacterial biofilm, colonization, double J stent, risk factors, urinary tract infection

Introduction

The indwelling stents are routinely used in urology practice to maintain ureteral patency. Nowadays the double J stents (DJS) are indispensable in modern urology practice and often used for the management of a wide range of circumstances, such as the relief of upper urinary tract obstruction, the prevention of stricture formation, the drainage of urinary tract leaks and for the prevention of post-surgical complications[1].

However, the use of these devices is often associated with several complications and mild morbidities such as dysuria, fever, suprapubic pain, urinary frequency, and urinary tract infections (UTIs), particularly when they are left in situ for prolonged time periods[2]. In some cases, infection associated with urinary stents can lead to significant morbidity, such as acute pyelonephritis, bacteremia, renal failure, and even death[3]. Ureteral DJS are synthetic biomaterials with suitable surfaces for bacterial colonization and the development of biofilm polysaccharides. Beneath these layers, bacteria grow rapidly, forming microcolonies, which results in different clinical outcomes. Bacterial colonization and biofilm formation play an essential role in the pathogenesis of stent-associated infection[4].

Patients with indwelling urethral catheters develop asymptomatic UTIs in 5–25% of the cases, while only about 3–5% develop symptomatic UTIs requiring antimicrobial drugs or removal of the catheters[5].

In our study, we investigated the microorganisms responsible for DJS colonization, bacteriuria, and the drug susceptibility of the isolates.

HIGHLIGHTS

- Prospective analysis study of patients following ureteral double J stent ablation.
- Diabetes was correlated with double J stent contamination with $P < 0.001$.
- The association between positive stent colonization and bacteriuria is significant.
- The mean duration of the use of double J stent is a strong risk factor for contamination.
- The most commonly isolated pathogens on stents were Gram-negative bacilli (53.2%).

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Annals of Medicine & Surgery (2024) 86:153–158

Received 31 August 2023; Accepted 26 October 2023

Published online 16 November 2023

http://dx.doi.org/10.1097/MS9.0000000000001477

We also tried to determine risk factors of DJS colonization, such as indwelling time, sex, age, and comorbidities.

Materials and methods

Study population and design

This study is a prospective analysis of a series of consecutive patients following DJS ablation.

For 5 months, all patients admitted for DJS ablation were included in this study; a total of 155 patients from our institution were enrolled between January 2023 and May 2023. Informed consent was obtained from each patient after an explanation of the aim of the study as well as approval from the local Ethics Committee (Ref: CEFMS 186/2023).

Bladder urine was collected in a sterile container prior to stent removal for a bacteriological exam. Stent ablation was performed under sterile conditions in an operating theater with the help of a cystoscope and foreign body forceps.

The indwelling stents were implanted and retained for periods of between 1 and 13 months, with a mean duration of 5 months. Two types of stents were used, polyurethane in 141 patients and silicone in 14 patients; the hospital's stent availability determines the choice of stent.

Patients with contaminated initial urine bacterial exam and those who did not give an informed consent were excluded from the study.

Bacteriological study

Probe sampling methods

For each stent collected, three parts were cut as follows: 3 cm from the renal part, 3 cm from the urethral part, and 3 cm from the bladder part. Each part was stored separately in sterile packaging. All probe tips were immediately sent to the microbiology laboratory within 1 h of sampling.

Each probe tip was collected in 1 ml of saline without unblocking the lumen and vortexed for 1 min. Next, 10 μl were inoculated onto fresh blood agar and cooked blood agar supplemented with IsoVitaleX and incubated for 48 h at ~35°C under 5% CO_2 for cooked blood agar. For the yeast, a Sabouraud culture medium was also used.

Interpretation of the results

After 48 h of the culture's incubation, we count the colonies. We consider as positive any monobacterial culture containing at least 10 colonies (corresponding to 10^3 CFU/ml), any pure culture containing yeasts and any culture containing two predominant species with at least 10 colonies each. Midstream urine (MSU) was obtained from these patients just before stent removal for bacterial identification.

Bacterial identification was carried out using conventional methods, that is, Gram staining, biochemical tests and Api identification microgalleries (BioMérieux, France) and using the Vitek2 automated system (BioMérieux, France).

Antibiotic susceptibility testing of strains incriminated in the superinfection of DJS was carried out using conventional agar diffusion techniques and Vitek2 cards (BioMérieux, France). Results were interpreted in accordance with the recommendations of the French Microbiology Society's Antibiogram Committee and the European Committee on Antimicrobial Susceptibility Testing (CASFM-EUCAST 2022).

Statistical study

Data capture and analysis were performed using IBM Statistical Package for the Social Sciences, version 25. Descriptive statistics were reported as frequencies for categorical variables and as means and standard deviations (SD) or median and inter-quartile range (IQR) for quantitative ones. Differences between groups were examined using the Chi-squared (χ^2) test to compare proportions. When this test was not applicable, the Fisher test was used.

Results

Indications of DJS implantation

The most important indication of stent insertion was stone disease treatment in 71 patients (45.8%), and the most performed procedure was ureteroscopy in 49 patients (31.6%). The second indication was urinary drainage for acute obstructive pyelonephritis (43.2%) (Table 1).

No correlation was found between the indication of stent implantation and stent contamination $P = 0.491$ (Table 2).

Association between patient's characteristics and positive DJS cultures

The mean age of the patients was 58 years ranging between 18 and 91 years. The mean age of patients with positive stent culture was 61.17 ± 12.82 versus 55.94 ± 10.32 when stent culture is negative, which is statistically significant ($P = 0.016$). 58.7% of the patients were male and 41.3% were female; sex ratio was 1.42. DJS were colonized in 25.2% of male patients and in 37.5% of female patients, which is not statistically significant ($P = 0.103$) (Table 2).

The mean duration of the use of DJS in patients with colonized stent culture is 6.45 ± 2.98 months and 4.06 ± 2.20 months in the others. The difference is statistically significant, $P < 0.001$.

Sixty-four patients (41.3%) have no medical history; for the others, the most important past medical history was diabetes mellitus (DM) in 70 patients (45.2%), followed by hypertension in 54 patients 34.8% and chronic renal failure (CRF) in 33 patients (45.8%). Tobacco was found in 71 patients

Table 1

Indications of DJS implantation

Indications	*n* (%)
Stone disease treatment	71(45.8)
Surgical treatment	13 (8.3)
Before SWL	9 (5.8)
URS	49 (31.6)
Acute obstructive pyelonephritis	67 (43.2)
Others	17 (10.9)
PUJ obstruction	3 (1.9)
Retroperitoneal fibrosis	8 (5.1)
Malignancy with ureteric compression	6 (3.8)
Total	155 (100)

DJS, double J stent; PUJ, pyeloureteral junction; SWL, shock wave lithotripsy; URS, ureteroscopy.

Table 2

Association between patient's characteristics and positive DJS cultures

Patients characteristics	Patients with positive stent colonization, n (%), N=47	Patients with negative stent colonization, n (%), N=108	P
Age (years)	61.17 ± 12.82	55.94 ± 10.32	0.016
Sex			
Male	23 (48.9)	68 (74.8)	0.103
Female	24 (51.1)	40 (62.5)	
Diabetes	40 (85.1)	30 (27.8)	**< 0.001**
Hypertension	17 (36.2)	37 (33.6)	0.818
CRF	13 (27.7)	20 (18.5)	0.201
Tobacco	24 (51.1)	47 (43.5)	0.386
Positive urine culture	14 (29.8)	0 (0)	**< 0.001**
Stone disease treatment past history	15 (31.9)	25 (23.1)	0.037
Types of stents			
Polyurethane	43 (91.5)	98 (90.7)	1
Silicone	4 (8.5)	10 (9.2)	
Indications			
Urolithiasis treatment	23 (48.9)	48 (44.4)	0.491
Pyelonephritis	20 (42.6)	47 (43.5)	
Others	4 (8.5)	13 (12.0)	
Stent part			
Renal	35 (28.5)	12 (67)	**< 0.001**
Ureteral	41 (33.3)	6 (33)	
Vesical	47 (38.2)	0 (0)	
Stent duration (months)	6.45 ± 2.98	4.06 ± 2.20	**< 0.001**

CRF, chronic renal failure; DJS, double J stent.

(45.8%). Only DM was correlated with DJS contamination with $P < 0.001$ (Table 2).

Ninety-five patients (61.2%) had a history of urolithiasis treatment, 34% with endourology treatment (ureteroscopy), 15 patients (11%) with surgical treatment (open and laparoscopic), 10% with both of them and finally 6% with shock wave lithotripsy (SWL). Past history of urolithiasis treatment was not correlated with stent contamination $P = 0.037$ (Table 2).

In 47 patients (30.3%), DJS bacterial colonization was positive (23 males and 24 females), and 14 patients of them (29.7%) had positive urine cultures, but no one was symptomatic; it was asymptomatic bacteriuria. In 108 patients, DJS were not colonized, and none of them developed bacteriuria. The association between positive stent colonization and bacteriuria is statistically significant ($P < 0.001$). The top part of DJS was colonized in 35 cases (28.5%), the middle part was colonized in 41 cases (33.3%) and the bottom part in 47 cases (38.2%). The correlation between the different parts of the stent and bacterial colonization is with $P = 0.001$. The number of colonized polyurethane stents was 43 (30.4% of polyurethane stents), and the number of silicone stents was 4 (28.5% of silicone stents), but the difference was not statistically significant ($P > 1$).

Bacteriological study

The most commonly isolated pathogens on stents were Gram-negative bacilli (53.2%) dominated by *Enterobacteriaceae* in 19 cases (55.2%) and Gram-positive cocci in 12 cases (25.5%) with *Enterococcus faecalis* in 10 cases. *Candida albicans* was isolated in 10 cases (Table 3). Co-infections were noted in three patients with the association of two bacterial or yeast species: *Escherichia coli* and *Proteus mirabilis* ($n = 1$); *Citrobacter koseri* and *E. faecalis* ($n = 1$); *C. albicans* and *E. faecalis* ($n = 1$).

In all cases, the three parts, renal, urethral, and bladder, were positive for the same bacteria or yeast. No discrepancy was noted between the bacteriological results of the three catheter tips.

The bacteriological results of urine cultures were positive in 14 patients, and the same pathogens were found in the DJS culture.

Enterococcus spp. was resistant to fluoroquinolones (80%), to cotrimoxazole (90%), and had high level of resistance to gentamicin (80%). Only the strain of *E. faecium* was resistant to ampicillin and imipenem. No resistance to glycopeptides was observed in the strains of *Enterococcus*. *Enterobacteriaceae* were extended spectrum beta-lactamase producers and carbapenemase in all *E. coli* strains. Resistance rates of enterobacteria were 60%, 50%, 20% and 10%, respectively, to fluoroquinolones, cotrimoxazole, aminoacids and fosfomycin. One strain of *E. coli* was resistant to all antibiotics except colimycin. *Pseudomonas aeruginosa* was resistant to ceftazidime and carbapenems in the two cases and susceptible to fluoroquinolones, fosfomycin and colimycin in all cases. *Acinetobacter baumannii* was resistant to imipenem and ceftazidime in one case.

Discussion

The use of indwelling stents in modern urology is frequent and indispensable.

It has been reported that bacterial colonization of ureteric stents is common, and it might be observed after only 1 day from stent insertion. This is due to the deposition of a host conditioning film on its surface composed of proteins, electrolytes, elements, and other substances. The colonization of stents is due to the adhesion of bacteria to those substrates[6]. Bacterial colonization plays an essential role in the pathogenesis of stent-associated infections[4]. As said earlier, stent-associated infections are often rare and asymptomatic; in some cases, they may be associated with high morbidity, fever, acute pyelonephritis, sepsis, CRF, and even death[2].

According to the literature, rates of bacterial stent colonization are variable; this is probably due to the existence of many factors related to patients, material of the stent, and the duration of the use may affect the contamination of the indwelling catheters. For Riedl *et al.*[7] and Farsi *et al.*[8] the incidence of stent colonization is 69.3% and 67.9%, respectively, while for Kehinde *et al.*[5] and Paik *et al.*[4] the rate of colonization is respectively 42% and 44% for Ozgur *et al.*[9], only 7.7% of DJS are colonized. In our series, the rate of colonization was 30.3%.

For many series, *E. coli* was the most common isolated microorganism responsible for stent colonization[2,4,5,10]; other reported series found that *Staphylococcus epidermidis* and Gram-positive cocci were the most found; this is probably due to urethral contamination[4]. *Enterobacteriaceae* encompass a broad spectrum of disease-causing potential, ranging from beneficial commensal microbiota to opportunistic pathogens that can inflict significant morbidity and mortality on compromised hosts. Their ability to invade and persist in the urothelium depends on several virulence factors and their ability to form biofilms[11]. Biofilm-forming bacteria are a common cause of recurrent and severe urinary tract infections and are generally multidrug-resistant

Table 3

Bacteriological results of urinary JJ catheter culture and urine culture

Microorganisms			DJS culture, *n* (%)	Urine culture, *n* (%)
Gram-negative bacilli, *N* = 25 (53.2%)	*Enterobacteriaceae N* = 19	*Escherichia coli*	8 (17)	4 (28.5)
		Proteus mirabilis	5 (10.6)	4 (28.5)
		Klebsiella pneumoniae	3 (6.3)	
		Citrobacter koseri	2 (4.2)	
		Enterobacter cloacae	1 (2.1)	
	Non-fermenting GNB, *N* = 6	*Pseudomonas putida*	2 (4.2)	
		Pseudomonas aeruginosa	2 (4.2)	
		Acinetobacter baumannii	2 (4.2)	
Gram-positive cocci, *N* = 12 (25.5%)	*Enterococcus*	*Enterococcus faecalis*	10 (21.2)	4 (28.5)
		E. faecium	1 (2.1)	
	Staphylococcus	*Staphylococcus epidermidis*	1 (2.1)	
Yeasts, *N* = 10 (21.3%)		*Candida albicans*	10 (21.2)	2 (14.2)
Total			47 (100)	14 (100)

DJS, double J stent.

bacteria. In our study, *Enterobacteriaceae* were the most important species, but *Enterococcus faecalis* and yeasts were the most important pathogens.

In elderly patients, some factors are associated with an increase in urinary infection, such as the colonization of the skin with Gram-negative organisms, hormonal modifications, especially in female patients, the augmentation of post-voiding residue, some drugs, and many others. In our study, age was correlated with DJS colonization ($P = 0.076$); for Paik *et al.*[4], there was no correlation between age and catheter contamination.

In our series, the patient's gender was not correlated with stent colonization. In the literature, the results are contradictory. For Paik *et al.*[4], male gender was correlated with more stent colonization, while for Bonkat *et al.*[12], female gender was a risk factor for catheter colonization.

In our study, we used two types of stent, polyurethane and silicone. The difference was not statically significant concerning the rate of contamination between the two types, but the number of silicone stents is much smaller, and conclusions cannot be drawn for Farsi *et al.*[8], polyurethane stents are associated with a higher risk of colonization.

Patients with DM, CRF, or both are considered to have compromised immune systems, rendering them more susceptible to colonization by various pathogens, particularly opportunistic ones like *Candida*[5]. For many authors DM and CRF are both risk factors for bacteriuria and stent colonization; for Kehinde *et al.*[5] those two factors are significantly associated with infection by opportunistic pathogens, moreover all the patients with candiduria had DM or CRF, and *Candida* spp. were not found in the specimens from healthy patients. For Akay *et al.*[10] and Al-Ghazo *et al.*[2], DM and CRF are both risk factors for stent colonization, while for Klis *et al.*[13] those two factors were not significantly associated with stent colonization; this is probably due to the small number of patients, which may have led to a lack of power to detect significant associations. In our study, only DM was a risk factor for DJS colonization ($P < 0.001$).

In our study, the duration of the use of DJS was significantly associated with their colonization. The rate of colonization was linearly associated with the duration of the stent use. Our results are in concordance with those found by Farsi *et al.*[8], the duration of stent use was divided into three periods: until 1 month, from 1–3 months and more than 3 months. The rate of stent colonization was 53.8%, 60% and 75%, respectively; the difference was statically significant ($P < 0.05$).

For Paik *et al.*[4], a statistically significant relationship was found between the duration of stenting and the rate of colonization. As the duration of stenting lengthened, the colonization rate increased ($P < 0.05$). Within 2 weeks of use, no stent was colonized; however, 25 stents (44%) were colonized after 2 weeks. For Kehinde *et al.*[5], patients were divided into three groups according to the stenting duration; results showed that stent colonization rate and bacteriuria were correlated almost linearly with the duration of stenting. The longer the stent was indwelling, the greater the number of patients infected or stents colonized. For Akay *et al.*[10], the stent colonization rate and urinary infection rate increased with the duration of the stent placement, although the difference was not statistically significant. For Lojanapiwat[14], most of the colonized stents were found when the indwelling time was more than 4 weeks. So, we encourage urologists to use DJS only when necessary and to remove it as soon as possible because the duration of the insertion is linearly associated with bacterial contamination[15].

The indication of DJS use was not a risk factor for stent colonization ($P = 1$), urolithiasis treatment was not associated with an increased risk of stent colonization, and even urinary drainage of acute pyelonephritis was not correlated with a higher risk of contamination, this is probably due to the early use of broad-spectrum antibiotics.

In our study, the renal, ureteral and bladder parts of DJs were respectively colonized by 74.4%, 87.2%, and 100%, and the difference was statistically significant ($P < 0.001$). Our results are supported by Zhang *et al.*[15] indeed, the rate of colonized stents was 82.9%, in which the bladder section had the highest positive rate (85.0%), followed by the renal pelvis section (67.3%) and ureter section (42.9%); the difference was statically significant ($P < 0.05$). Notably, Kehinde *et al.*[5] supported Zhang *et al.*'s findings, reporting the highest colonization rate in the bladder segment (34%), followed closely by the renal segment (31%). For Klis *et al.*[13] colonization rate was 100%, 96%, and 98%, respectively, for renal, ureteral, and bladder parts, but the difference was not statistically significant, which is in contrast with our results. These findings can be explained by the ascending spread of the bacterial biofilms along the catheter into the bladder and upper urinary tract and by the fact that the distal part of the DJS can be contaminated from the urethra, especially when the transurethral catheter is inserted or while handling[15].

For Paick *et al*.[4], no patient without bacterial colonization in the ureteral stent had bacteriuria, and the same pathogen was found in urine and stent culture; these results are consistent with our results. In our study, no patient with sterile DJS developed bacteriuria, and bacteriuria was positive in only 30% of patients with colonized stents. In 70% of the cases, DJS were colonized, while urine cultures were negative at the time of stent ablation. For Farsi *et al*.[8], Riedl *et al*.[12], and Akay *et al*.[10], urine culture and stent colonization were both positive in respectively 70%, 55%, and 65% of cases. For Paik *et al*.[4] positive urine culture was found in 60% of colonized stents. These results predict that sterile urine culture is not correlated with negative stent culture, but negative urine culture is almost associated with negative stent culture. Our study suggests that colonization of the stent is an essential step of urinary tract infection and precedes colonization in the urine. Bacterial stent colonization does not necessarily induce bacteriuria; the duration of catheterization and other factors may have an important role. For Kehinde *et al*.[5], stent colonization rate and bacteriuria are correlated almost linearly with the duration of stenting.

The prophylactic antibiotic must cover both Gram-negative and Gram-positive uropathogens. In our institution, ciprofloxacin as a broad-spectrum antibacterial drug, was given only during the stent insertion. In the literature, the duration of antibiotic prophylaxis is not clear. Al-Ghazo *et al*.[2] recommends 5 days, while Zhang *et al*.[15] suggest the use of antibiotic prophylaxis during the stent's carrying period in patients at risk of bacteremia, especially if the dwelling time is more than 6 weeks.

Antibiotic susceptibility testing in our study showed high resistance rates. Biofilm's role in antimicrobial resistance is highly complex and may significantly drive resistance. Bacteria living in a biofilm can exhibit a 10–1000-fold increase in antibiotic resistance compared to similar bacteria living in a planktonic state[16]. Patel[16], in a study examining antibiotic resistance of *Staphylococcus epidermidis* and *Klebsiella pneumoniae* in biofilms reported that 100% of isolates were susceptible to vancomycin when tested in a planktonic state, but when tested from a biofilm, nearly 75% of them were completely resistant to the same antibiotic.

The two main limitations of our study were the relatively small number of patients, which may have led to a lack of power to detect significant associations and the fact that some other factors that could have had a potential impact on urine and catheter colonization were not taken into account such as the respect of strict asepsis during stent insertion. Further prospective studies with a large number of patients are needed to determine the optimal duration of DJS use.

Conclusion

Ureteral DJS are the indwelling stents of choice for temporary urinary diversion; however, bacterial colonization seems to be an unavoidable event and many risk factors were incriminated. Literature results were sometimes contradictory; indwelling time is the only unanimous factor, so we recommend using DJS only if necessary and removing it as soon as possible. Multi-drug-resistant *Enterobacteriaceae* and *Enterococcus* are the most important pathogens found in both stent and urine cultures. Bacteriuria is almost associated with positive stent culture, suggesting that colonization of the stent is an essential step of colonization of the urine and precedes urinary tract infection[16].

Ethical approval

Ethical approval for this study (Ethical Committee No: CEFMS 186/2023) was provided by the Ethical Committee of the Faculty of Medicine of Sousse, Sousse, Tunisia, on 20 January 2023.

Consent

Written informed consent was obtained from the patients for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Sources of funding

None.

Author contribution

K.B. and M.M.: conceptualization; H.B.S.: methodology; N.K.: software and analysis; M.J.: validation; J.B.: writing – original draft preparation; A.Z.: writing – review and editing.

Conflicts of interest disclosure

The authors report no conflicts of interest.

Research registration unique identifying number (UIN)

Our work is registered in the Pan African Clinical Trials Registry 'PACTR' ID: PACTR202308911309456, pactr.samrc.ac.za.

Guarantor

Khaireddine Bouassida.

Data availability statement

No articles report those results.

Provenance and peer review

The paper was not invited.

Acknowledgements

The authors would like to thank Dr Rim Ghamem for her support and valuable advice.

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