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ORIGINAL PAPER

Ascorbic acid supplementation effectiveness in reducing Double-J ureteric stent encrustations. A multicenter perspective

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Summary *Background: Double J (DJ) Ureteric stent encrustation is a troublesome complication that may impede its removal. The proposed study aims to investigate the effect of ascorbic acid supplementation on reducing DJ stent encrustations and identify potential risk factors.*
Methods: A multi-center, non-concurrent cohort study involved patients who had DJ ureteric stents from July 2017 to January 2024. Group I comprised 359 patients who took 500 mg of ascorbic acid supplements three times daily that continued until the time of DJ removal. In contrast, Group II consisted of 483 patients who did not use the supplement. The study groups were compared in terms of patient demographics, stone criteria, double-J stent encrustations, and stent-related adverse events. KUB grading system for stent encrustations was utilized.
Results: The study enrolled 842 patients with a prevalence of stent encrustations of 20.43%. The mean K, U, and B scores were 2.14, 1.91, and 2.15, respectively, and the mean total K.U.B. score was 6.2 ± 2.91. The study groups were comparable in terms of patient demographics; however, nine patients (2.5%) in group I had stent encrustations, compared to 163 (33.7%) in group II, with a statistically significant difference ($p < 0.001$). Urinary tract infections (UTIs) were more prevalent in group II at 57.8%, compared to 30% in group I ($p = 0.02$). Lack of treatment with ascorbic acid male gender, and longer duration of indwelling stents were significant predictors of stent encrustations ($p < 0.05$).
Conclusions: Our study has demonstrated that ascorbic acid supplementation could reduce the incidence of encrustations on double-J ureteric stents. Lack of ascorbic acid administration, male gender, and prolonged stent indwelling time were significant predictors for stent encrustations.

KEY WORDS: *Double-J; Encrustation; Indwelling time; Urine acidification.*

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INTRODUCTION

Double-J (DJ) ureteric stent encrustations is an area that requires further investigations, as it is primarily multifactorial (1). The formation of biofilms and colonization by urease-producing bacteria (such as *Proteus*, *Pseudomonas*, and *Klebsiella*) may contribute to the development of encrustations (2, 3). However, encrustations have also been observed in sterile conditions, and the most common composition identified on DJ stents is not struvite but calcium oxalate, indicating that other factors could be involved (4, 5). Urine conditions, including pH, supersaturation of crystallizing substances, and a deficiency of crystallizing inhibitors, play a significant role, as DJ stents remain in constant contact with urine (4, 6). Numerous other factors have been linked to the formation of encrustations, with indwelling time being the most extensively studied (2, 7).
Encrustation of ureteric stents could lead to severe complications, that occurs in up to 13% of cases of prolonged indwelling time or forgotten stent (8). Marked encrustations could compromise its tensile strength, potentially leading to stent fragmentation during removal.
Furthermore, such encrustations may cause damage or avulsion of the ureter during the removal procedure, urinary tract infections, or even result in the loss of the renal unit if they cause chronic obstruction of stent drainage (2, 9, 10).
Various procedures may be necessary to retrieve neglected DJ stents, including *Shock Wave Lithotripsy* (SWL), ureteroscopy, and percutaneous techniques. Open surgery, on the other hand, is seldom required (11, 12).
Torrecilla et al. investigated the efficacy of a new oral medication in preventing DJ stent encrustations. The oral composition studied contained both urine acidifier and crystallization inhibitors, and they reported a significant decrease in stent encrustations (13).
Studies have indicated that oral Ascorbic Acid intake can lead to urine acidification (14, 15).
We conducted the current study to investigate the impact of daily Ascorbic Acid supplementation on reducing the incidence of encrustations on DJ ureteric stents. We highlighted the incidence of stent encrustations, predictive factors, and associated morbidities.

Materials and methods

A multi-center non-concurrent cohort study involved patients with DJ ureteric stents treated at three tertiary care hospitals. The study was conducted between July 2017 and January 2024, and the local institutional review board for the *Urology Department, Faculty of Medicine, Al-Azhar University*, approved the protocol (*Study Protocol ID Number: UroAzhar-021-12*).

The study included adult patients aged 18 years or older who underwent endourology procedures for stone management with the insertion of DJ ureteric stents. We prescribed a three-times-daily oral Ascorbic Acid dose of 500 mg (total 1500 mg per day) aiming to reduce DJ stent encrustation. The treatment was prescribed as a home medication on discharge after DJ stent insertion and continued until the time of DJ removal.

We excluded patients with silicone ureteric stents and those with incomplete files from our study.

Before DJ removal, every patient had a *kidney-ureter-bladder* (KUB) x-ray, while patients with neglected stents required a *non-contrasted computed tomography* (NCCT). Contrast imaging studies were occasionally necessary to obtain detailed calyceal anatomy. Laboratory investigations, including serum creatinine, complete blood count, coagulation profile, and urinary culture, were obtained. If the urinary culture results were positive, the patients were treated accordingly, and DJ stent removal was subsequently performed.

We used the scoring system proposed by *Arenas et al.* to assess the level and severity of DJ stent encrustations. The KUB system grades each portion of the stent individually on a scale of 1 to 5 based on the severity of the encrustation. This includes the proximal renal coil (graded as "K"), the ureteral shaft (graded as "U"), and the distal bladder coil (graded as "B"). The cumulative KUB score is obtained by adding the scores of all three portions of the stent, with a maximum score of 15 (16).

Patients received prophylactic antibiotics before undergoing DJ stent removal with spinal, general, or urethral topical anesthesia.

Double-J ureteric stents were removed using a cystoscope and forceps, sometimes with the help of SWL or ureteroscopy and laser fragmentation. In extreme cases, cystolithotripsy and percutaneous nephrolithotomy were necessary for stent removal. If the procedure was prolonged, the stent was replaced with a new one.

The cohort was divided into two distinct groups. Group I comprised 359 patients who demonstrated regular compliance with the daily oral ascorbic acid regimen. In contrast, Group II consisted of 483 patients who did not use the supplement.

The study groups were compared in terms of patient demographics, stone criteria, DJ stent encrustations, and stent-related adverse events. Perioperative complications were graded according to the modified Clavien-Dindo classification system (17). Neglected stents were defined as a duration of indwelling exceeding 6 months.

A logistic regression model was used to analyze the risk factors that may lead to DJ tent encrustations. The analyzed variables included patient demographics, laboratory profile (such as urine culture, serum creatinine, and blood sugar), indwelling time, and regular use of Ascorbic Acid supplement throughout stent indwelling.

Statistical analysis

The data was analyzed using Statistical Package for Social Science (SPSS) version 29 software.

Numerical data were summarized using means and standard deviations, while categorical data were summarized as numbers (percentages).

We used an independent t-test for normally distributed numeric variables, the Mann-Whitney test for non-normally distributed variables, and Chi-square and Fisher's exact tests for categorical variables.

A logistic regression analysis was done to identify predictors of stent encrustation. Univariate analysis was conducted for all variables expected to affect stent encrustations. The significant variables were included in the logistic multivariate regression stepwise model, presented by *odds ratio* (OR) and its *confidence interval* (CI). Results were considered significant when $p < 0.05$.

Results

The study involved 842 patients, with a mean age of 41.58 ± 17.42. Out of these, 172 patients (20.43%) developed stent encrustations. The mean K, U, and B scores were 2.14, 1.91, and 2.15, respectively, and the mean total

Table 1.
Patients' demographic data and outcomes in the study groups.

Variables	Group I (n = 359)	Group II (n = 483)	P value
Age, years, Mean (SD)	42.12 (16.06)	40.64 (18.10)	0.762
Gender, N (%)			
Male	219 (61%)	313 (64.8%)	0.24
Female	140 (39%)	170 (35.2%)	
History of urinary stone, N (%)			
No	38 (10.6%)	44 (9.1%)	0.5
Yes	321 (89.4%)	439 (90.9%)	
Kidney	181 (56.4%)	239 (54.4.2%)	
Ureter	92 (28.7%)	140 (31.9%)	
Kidney/ureter	48 (14.9%)	60 (13.7%)	
Indwelling time (days), Mean (SD)	199 (176)	328 (298)	< 0.001
Neglected Stents, N (%)	49 (13.6%)	120 (24.8%)	0.06
BMI, Mean (SD)	25.72 (2.84)	26.24 (2.62)	0.1
Preoperative serum creatinine, mg/dL			
Mean (SD)	1.16 (0.42)	1.14 (0.57)	0.16
Occurrence of double-J stent encrustations, N (%)			
Yes	9 (2.5%)	163 (33.7%)	< 0.001
No	350 (97.5%)	320 (66.63%)	
Perioperative complications according to modified Clavien-Dindo classification system, N (%)			
Storage LUTS (Grade I)	91 (25.3%)	191(39.5%)	0.02
UTI (Grade II)	108 (30%)	279 (57.8%)	0.06
Hematuria (Grade I)	129 (35.9%)	146 (30.2%)	0.76

BMI: Body mass index; SD: Standard deviation, LUTS: Lower urinary tract symptoms, UTI: Urinary tract infection.

K.U.B. score was 6.2 ± 2.91. The patient demographics and stone characteristics of the study groups were similar, as shown in Table 1. It was found that 2.5% of patients in group I presented with DJ stent encrustations, compared to 33.7% of patients in group II, with a statistically significant difference ($p < 0.001$).

Double-J stent encrustations were more frequent in males (78.49%). 135 out of 532 male patients (25.38%) developed DJ stent encrustations compared to 11.82% of female patients with a statistically significant difference ($p = 0.004$) (Table 2).

DJ stent encrustation was more frequent in patients with prolonged stenting time or neglected stents; the median duration of stenting time in cases with encrustations was 278 days compared to 119 days in those with no encrustations ($p < 0.001$) as depicted in Table 2.

Regarding DJ-associated adverse events, *urinary tract infection* (UTI) was more prevalent in group II at 57.8%, compared to 30% in group I ($p = 0.02$). Similarly, storage *lower urinary tract symptoms* (LUTS) were reported in 25.3% and 39.5% of groups I and II, respectively ($p = 0.06$). Hematuria was reported in 35.9% and 30.2% of cases in group I and II, respectively, with no statistically significant difference, as illustrated in Table 1.

Univariate analysis revealed that several variables may contribute to DJ ureteric stent encrustations. However, the multivariate logistic regression model demonstrated that lack of ascorbic acid intake, male gender, and longer duration of indwelling stent were significant predictors of stent encrustations ($p < 0.05$), as depicted in Table 3.

Table 2.
Demographic data of patients with and without stent encrustations.

Variables	Encrustation (n = 172)	No Encrustation (n =670)	P value
Age, years, Mean (SD)	41.92 (16.06)	40.84 (18.10)	0.65
Gender, N (%)			
Male	135 (78.49%)	397 (59.25%)	0.004
Female	37 (21.51%)	273 (40.75%)	
History of urinary stone, N (%)			
No	10 (5.81%)	72 (10.75%)	0.001
Yes	162 (94.19%)	598 (89.25%)	
Indwelling time (days), Mean (SD)	378 (321)	149 (28)	< 0.001
Neglected Stents, N (%)	132 (78.1%)	37 (21.9%)	< 0.001
Ascorbic acid intake, N (%)			
Yes	9 (5.2%)	350 (52.2%)	< 0.001
No	163 (94.8%)	320 (47.8%)	
BMI, Mean (SD)	26.12 (2.14)	25.74 (2.92)	0.2
Preoperative serum creatinine, mg/dL			
Mean (SD)	1.24 (0.4)	1.06(0.48)	0.18

BMI: Body mass index; SD: Standard deviation.

Table 3.
Univariate and multivariate logistic regression models for the variables associated with stent encrustations.

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	P value	HR (95% CI)	P value
Age	1.42 (0.69, 2.92)	0.334	---	---
Gender	0.56 (0.33, 0.95)	0.032	1.80 (1.11, 2.94)	0.018
Duration of indwelling stents/days	1.01 (1.00, 1.01)	< 0.001	1.01 (1.01, 1.01)	< 0.001
History of stone	---	0.9	---	---
BMI	0.99 (0.90, 1.08)	0.802	---	---
Urine acidification	0.03 (0.01, 0.08)	< 0.001	30.99 (12.70, 75.56)	< 0.001
UTI	1.71 (0.99, 2.96)	0.054	---	---
Mean (SD)	1.24 (0.4)	1.06 (0.48)	0.18	

BMI: Body mass index; UTI: Urinary tract infection.

Discussion

The encrustation of DJ stents can lead to significant clinical consequences that may impede the removal of the stents. The duration of stent placement is directly proportional to the probability of encrustation (1) (17-19). In some cases, this can result in complete encrustation, necessitating endourological procedures, SWL, or open surgery for stent removal (20, 21). According to some reports, the mere presence of a biofilm on a stent can intensify a patient's discomfort and lead to LUTS (3, 22). In this study, about 20% of patients with DJ ureteric stents had encrustations. Other studies have reported a prevalence rate from 9% to 76% (1, 11, 25, 26). The reason for this variation is unclear, but it may be due to differences in the population and the duration of indwelling time in each study. Nevertheless, most studies have shown a high prevalence of encrustations.

Torrecilla et al. conducted a study on the effect of urinary pH on the development rate of crystals and subsequent encrustations around the DJ stent. Their findings suggest that when urinary pH values are within the range of 5.5 to 6.2, the crystals development rate and encrustation formation are significantly reduced (13). Conversely, other researchers have reported that when urinary pH is less than 6.2, the risk of stent encrustation increases by 13-fold (23, 24).

The development of significant calcium phosphate deposits depends upon specific conditions in urine with a pH exceeding 6.2 and no bacterial colonization. Brushite deposits can accumulate in large quantities when urine has a high calcium concentration, a citrate deficit, and a pH level greater than 6.2. Such conditions can also lead to the occurrence of large calcium oxalate dihydrate crystals. Large hydroxyapatite deposits, on the other hand, can develop when calcium and magnesium concentrations are low (13).

According to certain reports, the intake of ascorbic acid has been observed to cause urine acidification without affecting serum pH levels. This acidification has been

associated with mild calciuria; however, this is balanced by an increase in the solubility of calcium phosphate in acidic urine. (14, 15).
Consequently, the decrease in the incidence of DJ stent encrustation resulting from daily ascorbic acid intake could be attributed to its role as a urine acidifier. This observation could be explained by the reduced rate of urinary tract infection and bacterial colonization in an acidified environment. These findings are consistent with earlier studies demonstrating a connection between a lack of acidification, urinary tract infection, bacterial biofilm formation, and consequent stent encrustations (13, 25, 26).
Some reports have shown significant hyperoxaluria in patients with calcium stone formation after high doses of oral ascorbic acid intake (2-10 g per day) (14). However, in our study, we used a daily dose of 1.5 gm.
The present study has demonstrated a considerable efficacy of daily oral administration of Ascorbic Acid, which could act as a urine acidifier, in mitigating the incidence of DJ ureteric stent encrustations. Our findings could be consistent with those reported by *Torrecilla et al.*, who demonstrated promising outcomes by using a novel compound comprising a urine acidifier and a crystallization inhibitor to decrease ureteric stent encrustation (13).
Our study found that male patients have a higher incidence of double-J ureteric stent encrustations, with a prevalence of 25.52%, compared to 11.82% in females. This trend can be attributed to hormonal differences and higher citrate levels in females (27, 28).
Several risk factors have been studied regarding the formation of encrustations on DJ stents, including recurrent urinary tract infections and stone recurrence. A higher prevalence of stent encrustations has been observed in individuals with a history of recurrent stones, as evidenced by numerous studies (1) although our study did not identify stone recurrence as a risk factor for stent encrustation.
As noted previously, the present study has demonstrated that patients with neglected ureteric stents are at an increased risk of developing stent-related complications, including recurrent urinary tract infections, stent fragmentation, and stent migration (20, 29, 30).
Numerous studies have explored the potential of Ascorbic Acid supplementation to reduce urine pH in patients suffering from recurrent urinary tract infections or stone formers with alkaline urine. However, no studies have assessed the impact of ascorbic acid supplementation on the incidence of ureteric double-J stent encrustations. Our research represents the first investigation of this nature and demonstrates that Ascorbic Acid supplementation can significantly reduce the incidence of ureteric DJ stent encrustations.

The study limitations

Despite the substantial sample size, this cohort study has limitations that warrant careful consideration. Firstly, the retrospective nature of the study may introduce potential recall bias. Secondly, there are notable omissions in specific data, including urinary metabolic measurements, urine pH values, and comprehensive analyses of stones and encrustations. Consequently, additional randomized controlled trials are warranted to further elucidate our findings.

Conclusions

This study demonstrates that daily oral supplementation with ascorbic acid can reduce the incidence of encrustations on double-J ureteric stents. Furthermore, the analysis identifies several significant predictors of stent encrustations, including lack of treatment with ascorbic acid, male gender, and extended stent indwelling time.

Declarations

Ethical approval and consent for participate: *The study followed ethical standards outlined in the Declaration of Helsinki and was approved by the Institutional Review Board of the Authors'Institute (protocol (Study Protocol ID Number: UroAzhar-021-12). Due to feasibility and unchanged review results, informed consent was waived for 842 individuals whose medical records were reviewed.*

Consent for publication: *Not Applicable.*

Availability of data and material: *The datasets used during this study are available from the corresponding author on reasonable request.*

Competing interests: *The authors state that they do not have any conflicting interest.*

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Authors' contributions: *All authors have made significant contributions to the study's conception and design, methodology, data acquisition, analysis, review, and interpretation. They have all read and approved the final version of the article and confirmed that all methods were conducted according to the relevant guidelines and regulations. Furthermore, all authors reviewed the manuscript.*

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