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Efficacy of Oral Potassium Citrate in Reducing Double-J Ureteric Stent Encrustations: A Retrospective Cohort Study from a Single Tertiary Care Center

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ABSTRACT

Double-J (DJ) ureteric stent encrustation is a significant complication in endourological practice. The role of oral potassium citrate in mitigating stent encrustations remains inadequately studied. **Objectives:** To evaluate the efficacy of oral potassium citrate supplementation in reducing DJ stent encrustations and identify associated risk factors. **Methods:** A retrospective cohort study was conducted at Gujranwala Teaching Hospital (October 2022 to October 2025) involving 504 patients with DJ stents. Group 1 (n=249) received oral potassium citrate (20 mEq twice daily) until stent removal; Group 2 (n=255) received no supplementation. Encrustation was assessed using the KUB grading system. **Results:** Overall encrustation prevalence was 18.05% (91/504) with a mean KUB score of 6.2 ± 2.90. Encrustation rates were significantly lower in Group 1 (5.2%) versus Group 2 (30.58%) (p<0.001). Urinary tract infections were more common in Group 2 (55.8%) than in Group 1 (30%) (p=0.006). Multivariate regression identified non-utilization of potassium citrate (adjusted OR: 0.52, 95% CI: 0.37-0.74), prolonged indwelling duration >180 days (adjusted OR: 3.45, 95% CI: 2.41-4.94), and male gender (adjusted OR: 1.62, 95% CI: 1.18-2.23) as independent predictors (all p<0.005). **Conclusions:** Oral potassium citrate supplementation significantly reduced DJ stent encrustations. Male gender, prolonged indwelling time, and non-utilization of potassium citrate were strong independent predictors. Prospective randomized trials are recommended to validate these findings.

INTRODUCTION

The field of endourology is greatly reliant on the use of double-J (DJ) ureteric stents since their introduction by Finney in 1978 [1]. These ureteral stents are predominantly deployed after stone disintegration procedures to maintain effective urinary drainage postoperatively. Ureteral stents come in various configurations, including single-J, double-J, magnetic-tip, and straight-tip designs [2]. They are further classified by material composition into synthetic (silicone and polyurethane) and biodegradable (polylactic acid and glycolic acid) categories [3]. These stents are typically placed for approximately six weeks and require replacement thereafter due to the development of stent-related complications, including infections, lower urinary tract symptoms, hematuria, and stent encrustations [4]. Prolonged indwelling may additionally result in stent fragmentation, obstruction, migration, and secondary stone formation [5]. Various interventional procedures, including extracorporeal shock wave lithotripsy (ESWL), ureteroscopy, and percutaneous approaches, may be required for the removal of neglected or encrusted DJ stents [6]. The pathophysiology of DJ stent encrustation is multifactorial and incompletely understood. Biofilm formation and bacterial colonization by urease-producing organisms such as Proteus, Klebsiella, and Pseudomonas species contribute to encrustation development [7]. However, calcium oxalate remains the most common

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encrustation component, suggesting that non-infectious mechanisms also play a significant role [8]. Changes in urinary composition, including supersaturation, deficiency of crystallization inhibitors, and metabolic derangements, promote encrustation even under sterile conditions [9]. Prolonged indwelling time is the most extensively studied risk factor, with significant encrustations potentially compromising stent tensile strength and leading to fracture during removal [10]. Furthermore, chronic encrustations may cause ureteral damage or avulsion during extraction and can result in complete obstruction of urinary drainage, potentially leading to loss of renal function [11]. In addition to surgical management of encrusted stents, various oral agents have been investigated for prevention. Elatreisy *et al*. studied ascorbic acid supplementation for reducing DJ stent encrustations[12]. Multiple studies have demonstrated the efficacy of potassium citrate in alkalinizing urine and preventing calcium oxalate and uric acid crystal formation [13, 14].

However, there is limited evidence specifically examining the impact of oral potassium citrate supplementation on DJ stent encrustation. This study aimed to evaluate the efficacy of oral potassium citrate supplementation in reducing the incidence of DJ stent encrustations and to identify predictive risk factors associated with stent encrustation in a large retrospective cohort.

METHODS

This was a single-centre, retrospective (non-concurrent) cohort study conducted at the Department of Urology, Gujranwala Teaching Hospital, from 22nd October 2022 to 23rd October 2025. The study was approved by the Institutional Review Board of Gujranwala Medical College (Protocol Number: Admin R.C. No. 5169; dated 2nd August 2022). Patients were counselled regarding the use of potassium citrate supplementation, potential adverse effects, and the study objectives. For the retrospective component, a waiver of written consent was obtained from the Institutional Review Board, given the non-interventional nature of data collection. The sample size was determined based on the number of eligible patients presenting during the study period, as this was a non-concurrent cohort study. A total of 504 patients met the inclusion criteria. The study included patients aged 18 years or older, irrespective of gender, who underwent endourological procedures with DJ stent placement for an intended duration of six weeks. Patients were excluded if they were pregnant, on digoxin therapy, had pre-existing hyperkalaemia, had a history of metabolic disorders, or had silicone ureteric catheters placed. Group assignment was based on clinical decision and patient compliance. Group 1 (n=249) comprised patients who were prescribed and demonstrated regular usage of oral potassium citrate (K-stone tablets, 20 milliequivalents twice daily, total dose 40 mEq/day) from discharge until DJ stent removal. Regular usage was defined as self-reported daily intake of the prescribed medication at each scheduled follow-up visit, confirmed by review of pharmacy dispensing records where available. Group 2 (n=255) comprised patients who did not receive or did not use the potassium citrate supplement. It should be noted that this was not a randomized allocation, and potential selection bias is acknowledged as a limitation of the study design. Before DJ stent removal, all patients underwent plain radiography of the kidneys, ureters, and bladder (X-ray KUB). Patients presenting beyond the six-week timeframe were additionally evaluated with non-contrast computed tomography (NCCT). The severity of DJ stent encrustation was assessed using the KUB scoring system described by Arenas et al., which grades each portion of the stent (K = upper coil, U = shaft, B = lower coil) individually on a scale of 1 to 5 based on encrustation severity. The total cumulative score ranges from 3 to 15. KUB scoring was performed by the operating urologist, who was not blinded to group allocation, which is acknowledged as a potential source of observer bias. Laboratory investigations, including complete urine examination, serum creatinine, complete blood count, serum electrolytes (potassium and calcium), and urine culture, were performed before the procedure and weekly for six weeks until the DJ stent removal. No cases of hyperkalaemia or other clinically significant adverse drug reactions were documented in either group during the monitoring period. No significant drug-drug interactions were identified. All patients received prophylactic ceftriaxone 1g intravenously before DJ stent removal under spinal or general Anesthesia. Stents were removed cystoscopically using forceps. ESWL, ureteroscopy, and laser fragmentation were not required in any patient. The primary outcome was the rate of DJ stent encrustation. Secondary outcomes included encrustation severity (KUB score), stent-related adverse events (urinary tract infections, haematuria), and identification of predictive risk factors. Forgotten or neglected stents were defined as those with an indwelling time exceeding six weeks.

Data were analyzed using SPSS version 29.0. Numerical data were summarized as means ± standard deviations (SD). Categorical data were expressed as frequencies and percentages. An independent t-test was used for normally distributed continuous variables, while the Mann-Whitney U test was applied for non-normally distributed variables. The chi-square test was used for categorical comparisons. Univariate logistic regression was performed to identify potential predictors of stent encrustation. Variables with $p<0.200$ on univariate analysis were entered into a

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multivariate logistic regression model. Results are presented as odds ratios (OR) with 95% confidence intervals (CI). The Hosmer-Lemeshow goodness-of-fit test was used to assess model calibration. Statistical significance was defined as p<0.005.

RESULTS

A total of 504 patients were enrolled in this study with a mean age of 40.56 ± 17.40 years. Of these, 91 patients (18.05%) developed stent encrustations. The mean K, U, and B encrustation scores were 2.04 ± 1.32, 1.90 ± 1.28, and 2.05 ± 1.35, respectively, with a mean total KUB score of 6.2 ± 2.90. The results present the demographic characteristics, stone specifications, and clinical outcomes for both study groups. The groups were comparable in terms of age, gender distribution, stone laterality, stone size, and stone site. The mean KUB sub-scores and total encrustation scores were significantly higher in Group 2 (non-supplementation) compared to Group 1 (supplementation). The encrustation rate was 5.2% in Group 1 compared to 30.58% in Group 2 (p<0.001). Urinary tract infections were more prevalent in Group 2 (55.8%) compared to Group 1 (30%) (p=0.060). Haematuria rates did not differ significantly between groups (p=0.070) (Table 1).

Table 1: Patient Demographic Data and Clinical Outcomes by Study Group

Variables	Group I (n=249), Mean ± SD / %	Group II (n=255), Mean ± SD / %	p-value
Age (Range)	40.2 ± 16.8 (19-71)	41.1 ± 17.9 (20-72)	0.740
Gender Male/Female	44%/56%	40%/60%	0.960
K score	1.80 ± 1.12	2.21 ± 1.45	0.020
U score	1.73 ± 1.08	2.30 ± 1.52	0.030
B score	1.42 ± 0.98	2.53 ± 1.61	0.010
Total Score	4.57 ± 2.34	8.03 ± 3.18	<0.001
Stone laterality (Right/Left)	53%/47%	49%/51%	0.910
Stone Size (mm)	8.1 ± 2.3	8.3 ± 2.5	0.670
Stone site (renal/ureteric)	59%/41%	61%/39%	0.450
Haematuria	34.9%	30.1%	0.070
Urinary Tract Infection	30%	55.8%	0.060
Encrustation	5.2%	30.58%	<0.001

SD = Standard Deviation, p-values < 0.005 are considered statistically significant

The study compares the demographic and clinical characteristics of patients with and without stent encrustations. DJ stent encrustations were significantly more frequent in males (70%) compared to females (30%) (p=0.004). Patients with encrustation had a significantly longer median stent indwelling duration (270 days) compared to those without encrustation (110 days) (p<0.001). Body mass index did not differ significantly between the groups (p=0.200) (Table 2).

Table 2: Demographic And Clinical Characteristics of Patients with and Without Stent Encrustations

Variables	Encrustation (n=91)	No Encrustation (n=413)	p-value
Gender Male/Female	70%/30%	36%/64%	0.004
Median stent duration (days)	270	110	<0.001
BMI (Mean ± SD)	26.12 ± 2.14	25.76 ± 2.92	0.200
UTI (%)	55.8%	30%	0.060
Hematuria (%)	34.9%	30.1%	0.070

SD = Standard Deviation, p-values < 0.005 are considered statistically significant

The study presents the results of the univariate logistic regression analysis. Several variables were identified as potential predictors of stent encrustation, including male gender (OR: 1.75, 95% CI: 1.42-2.85, p<0.001), potassium citrate intake (OR: 0.60, 95% CI: 0.45-0.87, p<0.001), and stent duration exceeding 180 days (OR: 3.80, 95% CI: 2.70-6.40, p<0.001) (Table 3).

Table 3: Univariate Logistic Regression Analysis of Variables Associated with Stent Encrustations

Variables	Odds Ratio (95% CI)	p-value
Age	1.01 (0.95-1.07)	0.870
Male Gender	1.75 (1.42-2.85)	<0.001
Potassium Citrate Intake	0.60 (0.45-0.87)	<0.001
Duration of Stent >180 Days	3.80 (2.70-6.40)	<0.001
BMI	1.03 (0.91-1.17)	0.620
UTI	1.45 (0.88-2.39)	0.140

CI = Confidence Interval; OR = Odds Ratio, p-values<0.005 are considered statistically significant

The study presents the multivariate logistic regression results. After adjusting for confounders, three variables remained independently significant predictors of stent encrustation: non-utilization of potassium citrate (adjusted OR: 0.52, 95% CI: 0.37-0.74, p<0.001), male gender (adjusted OR: 1.62, 95% CI: 1.18-2.23, p=0.003), and prolonged stent indwelling duration exceeding 180 days (adjusted OR: 3.45, 95% CI: 2.41-4.94, p<0.001). The Hosmer-Lemeshow goodness-of-fit test yielded a non-significant result (p=0.420), indicating adequate model calibration (Table 4).

Table 4: Multivariate Logistic Regression Analysis of Independent Predictors of Stent Encrustations

Variables	Adjusted Odds Ratio (95% CI)	p-value
Male Gender	1.62 (1.18-2.23)	0.003
Potassium Citrate Intake	0.52 (0.37-0.74)	<0.001
Duration of Stent >180 Days	3.45 (2.41-4.94)	<0.001

CI = Confidence Interval; OR = Adjusted Odds Ratio, Hosmer-Lemeshow goodness-of-fit test: p = 0.420. p-values<0.005 are considered statistically significant

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DISCUSSION

Double-J stent encrustation is a well-documented urological complication that increases patient morbidity and may necessitate advanced interventional procedures for stent removal, including extracorporeal shock wave lithotripsy, ureterorenoscopy, and percutaneous approaches [15]. The pathogenesis of encrustation is multifactorial; Singh *et al.* demonstrated that multiple factors contribute to encrustation formation on polyurethane stents, including prolonged indwelling time, chronic infections, recurrent stone-forming history, sepsis, and atypical renal tract anatomy [16]. Tunney *et al.* compared five different stent materials in in-vitro models of hydroxyapatite and struvite encrustation and reported that silicone stents demonstrated greater resistance to encrustation compared to other materials [17]. Tomer *et al.* identified two primary mechanisms underlying encrustation: bacterial colonization by urease-producing organisms (*Proteus, Klebsiella,* and *Pseudomonas* species) and elevated urinary mineral concentrations, including oxalate, phosphate, and calcium [7]. Kawahara *et al.* further demonstrated that stent caliber influences encrustation risk, with larger-caliber stents showing reduced encrustation rates [18]. Several oral supplementation strategies have been investigated for the prevention of DJ stent encrustations. Torrecilla *et al.* demonstrated promising outcomes using a compound comprising a urine pH modifier and a crystallization inhibitor to reduce ureteric stent encrustations in a randomized controlled trial [19]. Compositional analysis of encrustations by Scarneciu *et al.* and Giannossi *et al.* revealed that the majority of encrustations consist of calcium oxalate and uric acid crystals without evidence of significant infection, providing a rationale for the use of potassium citrate in encrustation prevention [20, 21]. The proposed mechanism involves the binding of calcium ions with citrate to form soluble complexes, thereby reducing the supersaturation of calcium salts and preventing crystal deposition on the stent surface. Importantly, potassium citrate alkalinizes rather than acidifies urine, which further inhibits uric acid crystal formation. It should be noted that while Tavoosian *et al.* conducted a randomized trial with a smaller sample (n=70), our retrospective cohort study provides complementary evidence from a larger patient population (n=504), though with inherent limitations associated with observational study design [22].

This study has several important limitations that should be carefully considered when interpreting the results. First, the retrospective design introduces the possibility of recall bias and incomplete data capture. Second, the non-randomized group assignment may introduce selection bias, as patients who adhered to potassium citrate supplementation may differ systematically from those who did not in ways not captured by the measured variables. Third, certain clinically relevant parameters, including serial urinary pH readings, comprehensive urine metabolic profiles, hydration status, and detailed compositional analysis of encrustations, were not consistently available and could not be included in the regression model despite being acknowledged as central to encrustation risk. Fourth, the KUB scoring was performed by the operating urologist without blinding to group allocation, introducing potential observer bias. Fifth, the sample size was based on eligible patients during the study period rather than a formal a priori power calculation, which may affect the generalizability and statistical power of the findings. Future prospective, double-blinded, randomized controlled trials with formal power calculations, objective adherence monitoring (such as urinary citrate levels), serial urinary pH measurements, comprehensive metabolic profiling, blinded outcome assessment, and longer follow-up periods are recommended to validate and extend these findings. Multi-center studies would further enhance the generalizability of the results.

CONCLUSIONS

This study demonstrates that oral potassium citrate supplementation is associated with a significant reduction in the incidence of DJ ureteric stent encrustations. Non-utilization of potassium citrate, male gender, and prolonged stent indwelling time were identified as strong independent predictors of stent encrustation on multivariate analysis. These findings support the consideration of potassium citrate supplementation as an adjunctive strategy for encrustation prevention, although further prospective randomized studies are warranted to confirm these results.

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Authors' Contribution

Conceptualization: MI
Methodology: MI, UKC, IBM
Formal analysis: UKC, TH
Writing and Drafting: MI, IBM
Review and Editing: MI, UKC, TH, IBM, RNA

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

All the authors declare no conflict of interest.

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