Do ureteral stent diameter and length or patient demographics play a role in stent encrustation?

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Abstract

Introduction: Retained ureteral stents may constitute a technical challenge. The purpose of this study was to analyze the patient population with retained ureteral stents with regards to stent sizes to better understand if these factors could play a pivotal role in their encrustation.
Methods: After institutional review board approval, we retrospectively analyzed the data of patients who underwent multimodal surgical procedures for the removal of retained ureteral stents from 2010–2018. The primary outcomes analyzed were ureteral stent length and diameter, location of stent placement, and patients' demographics as potential etiologies for encrustation.
Results: We included 30 patients with 32 encrusted ureteral stents and 37 patients with 46 forgotten non-retained ureteral stents. Indications for stenting included urolithiasis, malignancy, pregnancy, ureteral stricture, and ureteropelvic junction obstruction. Stent diameters ranged from 6 Fr. to 8.5 Fr. Stent lengths ranged from 22 to 30 cm, and multilength stents were used too. Smaller diameter stents were less likely to be retained when compared to larger diameter stents (>6 Fr.) (p=0.002). Overall stent length was not found to be significant (p=0.251); however, the difference in stent surface area differed by over 1cm (p<0.001). Patients who were uninsured were more likely to have retained stents (p=0.003). Patients who reside with longer commuting distance to the main academic medical center were more likely to have retained stents (p=0.010).

Conclusions: Retained ureteral stents could be avoided. Taking into consideration ureteral anatomical variation among patients, smaller diameter stents and smaller surface area may prevent encrustation. Uninsured patients, with farther distance to seek medical care, and females are the most at risk.

Introduction

Ureteral stents represent a minimally invasive alternative to preserve urinary drainage and play a vital role in relieving urinary obstruction due to urolithiasis, malignancy, pregnancy, stricture, trauma and any obstructive uropathy. The vast majority of stents are removed by the urologists in the outpatient clinic, in the operating room, or sometimes by the patients (stent on a string), one to two weeks after placement [1,2]. However, patients with chronic indwelling stents would require stent exchanges at 3–6-month intervals [1,2]. Ureteral stents are generally well tolerated by patients but complications such as flank and suprapubic pain, hematuria, dysuria, and increased frequency are seen [1,2]. Retained stents and stent encrustation are uncommon and more severe complications may be avoided with timely follow up. Divakaruni et al identified significant associations with forgotten stents in males and patients without insurance [3]. With encrustation, urologists often witness an increased difficulty in stent removal, morbidity, and sometimes mortality. A multi-modal approach is then often required for their management including shockwave lithotripsy, percutaneous nephrolithotomy, and ureteroscopy.

Previously published studies analyzing retained ureteral stents emphasize on the complication rates, complexity in management, and possible preventive measures [4,5]. Several studies have also investigated the correlation between stent length and diameter with stent-related symptoms and factors associated with encrustation [4]. However, the association between patient and stent characteristics on the development of retained stents remains unclear.

The purpose of this study is to analyze a patient population with retained stents at a major university-based academic medical center, in order to better understand if patient or stent characteristics are correlated with stent encrustation.

Methods

After IRB approval, we retrospectively reviewed all charts of patients who underwent adjunctive surgical procedures for the removal of retained ureteral stents and patients who had ureteroscopic procedures with uncomplicated stent removals from January 2010 to June 2018 at a single academic institution. Patients were included if they had an indwelling stent that could not be removed via cystoscopy in the clinic and required additional multi-modal procedures.

Patient demographics, relevant past medical history, including insurance type, and details regarding surgery were obtained from the hospital and clinic charts. Stent characteristics including diameter and length, indication for placement, date of insertion, and date of removal

were also recorded from charts. Preoperative imaging records were reviewed to determine the presence of encrustation. All patients underwent surgery after negative urine cultures were obtained. Surgical data included the procedure type, number of procedures, operative time, stone location, and length of hospital stay.

The primary outcomes were to analyze ureteral stent length and diameter, location of stent placement, and patients' demographics as potential etiologies for stent encrustation requiring adjunctive surgical approaches. Stent surface area was calculated using $2\pi(1/2\text{french})(\text{length})+ 2\pi(1/2\text{french})^2$.

All statistical analyses were conducted using a combination of SPSS version 26 and Microsoft Excel. Univariate analysis included Pearson's chi-square test for categorical variables and t-test and one way ANOVA for continuous variables.

Results

There were 30 patients with 32 retained ureteral stents and 37 patients with 45 non-retained ureteral stents totaling 67 patients and 78 stents over the eight-year study span. Among patients with retained stents, 12 were male and 18 were female. The control group consisted of 22 females and 15 males. Three patients presented at two separate occasions with retained stents, and two patients had bilateral retained stents. Females were more likely to have retained stents (p=0.492) but there was no statistical difference. There was a significant difference between the average age of those patients with a retained stent, where females were younger at age 40.9±15.1 vs males age 53.9±10.5 years old (p=0.016) (Table 1). Indications for stent placement included urolithiasis, malignancy, pregnancy, stricture, and ureteropelvic junction obstruction. Half of our patients with retained stents had a prior history of urolithiasis. Seventeen patients had stents placed at our institution and 11 patients had stents placed at outside hospitals. The average duration of retained stents were 11.2 ± 11.3 months (ranging from 2 to 264 months) (Table 2A).

Patients with non-retained stents had them removed in the clinic, in the OR, or self-removed them. Stent diameters ranged from 6 Fr to 8.5 Fr and stent lengths ranged from 22 to 30cm. Nine patients in the control group received multi-length stents. Smaller diameter stents were less likely to be retained as compared to larger diameters (p=0.002). The average stent length for a non-retained stent was 26.5 cm vs a retained stent of 27.33 cm (p=0.251) (Table 2A); however, chi squared analysis showed that 24 cm stents were strongly associated with non-retention compared to the 30 cm stents (p=0.054). Additionally, we found that 28 cm stents were less likely to be retained than 30 cm stents (0.094) (Table 2B). Although this is not statistically significant, it may be clinically relevant when selecting a stent length. Stent surface area was also compared in the two populations, where non-retained stents had a surface area average of 604.8 mm^2 compared to those who were retained at 706.6 mm^2 (p<0.001). The average time of forgotten non-retained ureteral stents was 21.4 ± 30.8 months (Table 2A).

All patients with retained stents had encrustation visible on imaging and required procedures in the operating room for their removal. Mean operating time was 109 ± 84 minutes (Table 3). The most common procedure performed was cystolitholapaxy (25 patients) (80.6%) with 21 patients requiring more than one procedure. Isolated upper coil encrustation occurred in 3 patients with retained stents and only required 1 procedure for clearance. Patients with isolated lower coil encrustation and upper and lower encrustation were more likely to require multiple procedures for stent clearance (Table 3), (Fig.1, 2): SWL combined with cystolitholapaxy: 13, URS combined with cystolitholapaxy: 4, PCNL combined with URS: 2, PCNL combined with URS and cystolitholapaxy: 1, SWL combined with bilateral tandem stents, cystolitholapaxy, URS, right laparoscopic ureterolithotomy: 1. (Fig.3, 4).

Fifteen percent of patients with retained stents had a prior history of stones. BMI did not correlate with retention rates. Patients who were uninsured were more likely to have retained stents as compared to insured patients (p=0.003) and the distribution of insurance types were significantly different (Table 4). Patients who lived further away from our institution were more likely to have retained stents compared to patients who lived closer (93.6 vs 53.5 miles, p=0.010).

Discussion

Ureteral stents play a vital role in preserving urinary drainage in numerous urologic conditions. Retained ureteral stents can form encrustations and difficulties in their removal. Some stents can even fracture if left for a prolonged time leading to unnecessary injury risk in the kidney [6]. Removal often requires a multi-modal treatment approach with an increased morbidity and mortality. A better understanding of patients who have an increased likelihood for developing retained stents may allow for earlier identification of those at risk and better communication for optimal follow-up. We analyzed the patient population with retained stents to better understand if patient or stent characteristics are correlated with retained stents. Patients who are female, have a past medical history of stones, those who are uninsured and those who live further away from our institution were more likely to have retained stents when compared to our control group. Age and BMI did not correlate with retained stents. Larger diameter and larger surface area of stents also had higher retention rates. All patients with retained stents had encrustation visible on imaging. The most common procedure in our retained stent population was cystolitholapaxy with 75% of patients requiring more than one procedure. Patients with lower coil encrustation were more likely to require multiple procedures.

In our study, female patients were more likely to have retained stents when compared to the control group but this was not statistically significant. This finding differs from Divakaruni et al. who found that men were almost three times more likely to have retained stents [3]. Other studies have found no significant differences in gender when comparing retained and non-retained stents [5,7]. Jin et al performed a meta-analysis from 1970 and 2005 reviewing patient noncompliance with medical therapy. They found that gender had no effect on compliance [8]. Our

finding may be limited by the small sample size of retained stent patients. Altogether, gender may not have a significant impact in this setting.

Half of our patients with retained stents had a prior history of urolithiasis. Patients with history of urolithiasis have almost a three times increased risk of encrustation of ureteral stents [9]. Jain et al found that 93% of patients with severe encrustations had history of urolithiasis [7]. The early identification of patients that are more likely to develop encrusted retained stents may help reduced the burden of multiple endoscopic procedures often required to successfully treat these patients.

Our study found that uninsured patients and those who live further away from our academic medical center were more prone to develop retained stents. Divakaruni et al found that those without health insurance were six times more likely to have forgotten stents [3]. Patients who have financial or geographic restraints, in addition to transportation issues are therefore at higher risk. Communication about the importance of timely removal of stents is critical. The present study found no significant difference in age and BMI between retained and non-retained stent groups. These findings are consistent with other studies comparing retained and non-retained stents [5,8].

We found that 75% of patients in the retained stent group required more than one procedure. In comparison, Jain et al found 17.65% of patients in the retained stent group required at least 2 endoscopic procedures for stent removal [7]. Aravantinos et al reported a median of 2.1 procedures per patient for removal of retained stents [10, 11]. These findings highlight the significance of identifying high risk patients prior to presenting with a retained stent.

In our study, patients with isolated lower coil encrustation and upper and lower coil encrustation were more likely to require multiple procedures for stent clearance as compared to isolated upper coil encrustation. Jain et al reported that isolated lower coil encrustations were less likely to require multiple procedures for clearance and often sufficiently treated with cystolitholapaxy or cystolithotripsy [7]. Prior studies have reported that encrustation is more common and dense in the upper coil [12, 13], due to better peristalsis in the lower urinary system [11]. Proximal stent encrustation often predicts the need for multiple procedures due to the need for more complex ureteroscopy or the need to convert to percutaneous nephrolithotomy as well described by Weedin et al [14]. In the Jain et al study, all patients requiring multiple procedures for retained stent removal had upper coil involvement [7]. Our findings are limited by our small sample size of three patients with isolated upper coil encrustation.

The present study found that smaller diameter stents were less likely to be retained as compared to those with larger diameters. Stent length also showed longer stents had higher retention rates when compared to the control group. This is the first study to our knowledge comparing stent length and diameter with retention rates.

This study identifies patients and stent characteristics that place patients at an increased risk of developing a retained stent. The retrospective nature of this study presents a limitation

that relies on the accuracy of data within patient charts. Stone chemical analysis was not reported stone extraction and sampling was not performed in all patients The small cohort and single institution review may prevent generalizability to other settings. Future research could include a prospective analysis of various prevention strategies including SMS messaging notification systems for patients, the implementation of biodegradable stents or a standardized protocol of discharge instructions for patients with ureteral stent placement. In parallel, urologists should be able to predict ureteral length based on pre-operative computed tomography imaging, or based on intra-operative findings (retrograde pyelograms, measurements noted on open-ended catheters that are inserted or upon withdrawing the ureteroscope). Longer stents and wider stents have a larger contact surface where urine and chemical deposits may perhaps induce encrustation more extensively. Future studies would be needed to possibly evaluate newer stent material, and coil configurations allowing for reduced contact surface and encrustation rates.

Conclusions

Retained ureteral stents could be avoided. Taking into consideration ureteral anatomical variation among patients, using shorter stents with smaller diameter stents may prevent encrustation. Uninsured patients, with farther distance to seek medical care and patients with transportation issues are at higher risk. Identifying patients who are at high risk of developing retained stents may aid healthcare providers in properly allocating time and resources to help prevent this iatrogenic condition.

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Figures and Tables

Table 1. Patient demographics				
	Retained	**Non-retained**	**Total**	**Significance**
Sex, n (%)				
Male	12 (44.4)	15 (55.6)	27	
Female	18 (45.0)	22 (55.0)	40	0.492
Age (years)				
Male	53.9			
Female	40.9			0.016

Sixty-seven patients were analyzed in our study. The sex percentages and age differences in groups based on stent status is shown

Table 2. Stent characteristics				
		Retained	**Non-retained**	**Significance**
Average duration, months ± SD (range)		11.2±11.3 (2–264)		
Diameter (French)		7.1	6.4	0.001
Length (cm)		27.3	26.6	0.251
Surface area (mm^2)		706.6±119.2	604.8±73.0	0.001
Length (cm)				
24 vs. 26				0.633
24 vs. 28				0.681
24 vs. 30				0.054
26 vs. 28				0.901
26 vs. 30				0.178
28 vs. 30				0.094

Stents time retention, diameter, length, surface area is all compared when retained. Length was further analyzed into subgroups of each size and compared. SD: standard deviation.

Table 3. Operation characteristics	
Time ± SD (minutes)	109 ± 84
Procedure, n (%)	
ESWL	19 (61.3)
Cystolitholapaxy	25 (80.6)
Ureteroscopy	7 (22.6)
PCNL	1 (3.2)

The operating total time and type of procedure needed to remove the retained stent. ESWL: extracorporeal shockwave lithotripsy; PCNL: percutaneous nephrolithotomy; SD: standard deviation.

Table 4. Insurance coverage, patients with retained stents			
	Confirmed	**Stent removal**	
	Yes	**No**	**Total**
Insurance	0	4	4
None	11	16	27
Medicaid	23	4	27
Medicare	2	4	6
Free care	1	1	2
Workers' comp	1	0	1
Private	5	3	8
Prisoner	2	0	2
Total	45	32	77