JOURNAL OF ENDOUROLOGY
Volume XX, Number XX, XXXXXX 2019

Pp. ■■■–■■■
DOI: 10.1089/end.2019.0138

Impact of the Timing of Ureteral Stent Placement on Outcomes in Patients with Obstructing Ureteral Calculi and Presumed Infection

Cory Faw, BS, Julian Wan, MD, John M. Hollingsworth, MD, MS, Sapan N. Ambani, MD, Khurshid R. Ghani, MD, MS, William W. Roberts, MD, and Casey A. Dauw, MD

Abstract

Objective: To understand how time to stent placement impacts outcomes in patients with obstructing ureteral stones and concern for infection.

Materials and Methods: Using a prospective urology consult institutional database (2011–2016), we identified patients who presented to the emergency department (ED) with an obstructing ureteral stone, met two or more systemic inflammatory response syndrome (SIRS) criteria (temperature [T] $>38°C$ or $<36°C$, heart rate >90 beats per minute, respiratory rate >20 breaths per minute, white blood cell count $>12\,k/\mu L$ or $<4\,k/\mu$), and underwent stent placement. The primary outcome of interest was impact of stent timing on intensity of care (need for intensive care unit [ICU]) as well as overall length of stay (LOS).

Results: Forty-eight patients were identified who met the study criteria. Overall, 58.3% had positive urine cultures. There was no difference between groups with across a range of clinical variables. While the need for ICU admission did not differ between groups, those patients who had a ureteral stent placed within 6 and 10 hours of ED arrival had a significantly decreased LOS (35.6 hours *vs* 71.6 hours, $p=0.01$; 45.7 hours *vs* 82.4 hours, $p=0.04$) relative to those patients who were stented outside these intervals.

Conclusion: In patients with an obstructing ureteral calculus and concern for infection, there is a beneficial effect to timelier stent placement in the form of decreased overall LOS.

Keywords: ureteral stent, infection, hospitalization

Introduction

Kidney stone disease represents a growing public health concern, affecting 1 in 11 Americans; a rate that has doubled over the past 15 years.[1] While many patients with symptomatic kidney stones can be managed expectantly, a proportion of patients will need surgical intervention: an option that has become more frequently used during the past 20 years.[2] One such situation involves patients presenting with an obstructing ureteral stone and concern for sepsis. In these cases, urgent renal decompression is warranted to avoid patient morbidity or mortality.[3,4]

While the necessity of renal decompression in the setting of an obstructing ureteral stone and sepsis is not subject to debate, less is known about how delays in renal decompression may affect patient outcomes. Prior studies indicate that patients who present with an obstructing ureteral stone and sepsis have increased rates of mortality when ureteral stent placement is delayed more than 48 hours.[5] While these findings are profound, little is known regarding how delays in ureteral stent placement in early stages of patient care may affect health outcomes.

We thus sought to better characterize how patient health outcomes may be affected by the time elapsed before ureteral stent placement. Using a validated urologic consultation database, we identified patients presenting to the emergency department (ED) with an obstructing ureteral stone and concerns for sepsis. We then determined how the time to stent placement impacted both the intensity of the subsequent hospitalization as well as overall length of stay (LOS).

Materials and Methods

Data source

We utilized a validated, prospectively maintained urologic consult database to identify patients presenting to the ED at our institution who had a urologic consultation for an obstructing ureteral calculus between January 1, 2011, and

Department of Urology, University of Michigan, Ann Arbor, Michigan.

January 1, 2016.[6] This comprehensive database captures all ED, inpatient, and intraoperative urologic consultations including data such as presenting diagnosis and need for surgical intervention. The database itself is audited to verify accuracy on a monthly basis.

Study population/patient demographics

Our study population consisted of patients presenting to the ED with a unilateral, obstructing ureteral stone and at least two systemic inflammatory response syndrome (SIRS) criteria (temperature [T] >38°C or <36°C, heart rate [HR] >90 beats per minute, respiratory rate [RR] >20 breaths per minute, white blood cell [WBC] count >12 k/μL or <4 k/μ) who subsequently underwent surgical decompression via ureteral stent placement. We chose to use the SIRS criteria as it represents a constellation of findings that suggest concern for systemic infection, thus indicating potential need for more urgent urologic consultation and intervention. For consistency, we selected the first set of vitals taken upon entry to the ED and the earliest WBC count recorded for the hospital encounter. We excluded patients treated nonsurgically, those who did not receive a CT scan, and those who underwent other forms of renal decompression (i.e., percutaneous nephrostomy tube placement).

We characterized patients across a range of demographics and clinical data, including age, gender, and body mass index. Relative comorbidity was assessed using the American Society of Anesthesiology (ASA) score.[7] Stone size was established by using maximal stone dimension based on CT. Microbiology data (urine and blood cultures) were also ascertained from chart review and were defined as ''positive'' if >100,000 colony-forming units were identified in a properly collected specimen.

Outcome measures

Our primary outcome of interest was to assess whether the time from the ED arrival to ureteral stent placement had any impact on subsequent intensity of hospitalization. In particular, we compared those patients stented within 6, 10, and 14 hours with those patients in whom stent placement was performed beyond these intervals. To measure time to stent placement, we determined the difference between the time patients were admitted to the ED and the start time of the surgical procedure for ureteral stent placement. In a similar manner, we also measured the time to urologic consultation. Hospitalization intensity was evaluated by determining whether subsequent admission to an intensive care unit (ICU) was required. We also measured overall LOS as time from hospital admission to time of discharge.

Statistical analyses

Statistical analyses were conducted using IBM SPSS 24 software (IBM Corporation, Armonk, NY) using the Pearson chi-squared test and independent *t*-test for categorical and continuous variables, respectively. We performed two-sided significance testing with the alpha set to 0.05 to represent statistical significance. The institutional review board approved this study based on no more than minimal risk to patients (HUM00106888).

Results

We identified a total of 48 patients who presented with an obstructing ureteral stone, met at least two SIRS criteria, and underwent ureteral stent placement. Within the cohort, the mean patient age was 50.9 years, 40.0% were male gender, and stone size was 5.8 mm (Table 1). Among the entire population, the mean T, HR, RR, and WBC upon admission to the ED were 37.2, 93.3, 19.7, and 15.4, respectively. In total, 58.3% of patients were found to have positive urine culture, which predominantly contained *Escherichia coli* (50.0%), *Staphylococcus* (14.3%), and *Klebsiella* (14.3%). Blood cultures were positive in 53.6% (15) of these patients with a similar spectrum of organisms and correlated with the positive urine culture in all cases. Overall, 6 (13.0%) patients required ICU admission and the mean LOS was 66.4 hours. There were no instances of mortality.

Of the 48 patients, 7 (14.6%), 21 (43.8%), and 30 (62.5%) underwent ureteral stent placement within 6, 10, and 14 hours of their admission to the ED, respectively. There were no differences between groups with regard to gender, age, or comorbidity (Tables 2–4). Patients were most often admitted to the urology service ($n = 40$, 83.3%), whereas the remainder were admitted to nonurologic services. Patients who were stented within 6 hours were noted to have a significantly higher initial T, HR, and more diminutive stone size relative to those patients stented after 6 hours. Those patients stented within 10 hours were also found to have a significantly higher HR when compared with those patients stented after 10 hours. There was no significant difference observed in initial vitals in those patients stented before or after 14 hours.

In all cohorts, patients who had a timelier urologic consultation were found to have a statistically decreased time to stent placement ($p < 0.02$). While the need for ICU admission did not differ between groups, those patients who had a ureteral stent placed within 6 and 10 hours had a significantly decreased LOS (35.6 hours *vs* 71.6 hours, $p = 0.01$; 45.7 hours *vs* 82.4 hours, $p = 0.04$) relative to those patients who were

TABLE 1. CLINICAL AND DEMOGRAPHIC CHARACTERISTICS OF THE COHORT

	Entire cohort (N = *48*)
Age (years)	50.92
Gender	0.40
BMI	30.48
Diabetes	0.15
American Society of Anesthesiology score	2.42
Stone size (mm)	5.79
Positive urine culture	0.58
Admission temperature (°C)	37.22
Admission heart rate	93.31
Admission respiratory rate	19.73
Admission WBC	15.36
Time to urology consult (hours)	7.59
ICU admission	0.13
Hospital duration (hours)	66.36

BMI = body mass index; ICU = intensive care unit; WBC = white blood cell.

Table 2. Comparison of Patients Stented Before or After 10 Hours

	Before 10 hours (N=*21*)	*After 10 hours* (N=*27*)	p
Age (years)	49.01	51.78	0.62
Gender	0.38	0.41	0.85
BMI	30.63	30.36	0.90
Diabetes	0.14	0.15	0.96
American Society of Anesthesiology score	2.38	2.44	0.73
Stone size (mm)	5.48	6.04	0.48
Positive urine culture	0.62	0.56	0.65
Admission temperature (°C)	37.51	36.99	0.08
Admission heart rate	100.57	87.67	0.02
Admission respiratory rate	19.05	20.26	0.24
Admission WBC	17.25	13.89	0.14
Time to urology consult (hours)	4.93	9.67	0.01
ICU admission	0.14	0.11	0.74
Step-down care	0.76	0.93	0.11
Hospital duration (hours)	45.71	82.41	0.04

Table 4. Comparison of Patients Stented Before or After 14 Hours

	Before 14 hours (N=*30*)	*After 14 hours* (N=*18*)	p
Age (years)	50.43	51.72	0.75
Gender	0.33	0.50	0.25
BMI	30.5	30.44	0.98
Diabetes	0.17	0.11	0.60
American Society of Anesthesiology score	2.30	2.61	0.13
Stone size (mm)	5.60	6.11	0.54
Positive urine culture	0.67	0.44	0.13
Admission temperature (°C)	37.39	36.94	0.15
Admission heart rate	96.60	87.83	0.17
Admission respiratory rate	19.27	20.50	0.31
Admission WBC	16.38	13.66	0.25
Time to urology consult (hours)	5.21	11.56	0.02
ICU admission	0.17	0.06	0.26
Step-down care	0.77	1.00	0.03
Hospital duration (hours)	49.75	94.04	0.06

stented outside this interval. After 14 hours, there was no statistical difference in LOS (49.8 hours *vs* 94.0 hours, $p=0.06$) (Table 4).

Discussion

This retrospective study showed that timelier ureteral stent placement is associated with a shorter LOS in patients presenting with at least two SIRS criteria and nephrolithiasis. This benefit to urgent stenting was noted as early as 6 hours following the ED presentation and trends toward persistence at the 14-hour time. Furthermore, the patients who were stented within 6, 10, and 14 hours of admission had more expeditious urologic consults compared with their counterparts, indicating that early urologic consultation is vital to ensure prompt intervention.

Table 3. Comparison of Patients Stented Before or After 6 Hours

	Before 6 hours (N=*7*)	*After 6 hours* (N=*41*)	p
Age (years)	48.00	51.41	0.54
Gender	0.29	0.41	0.52
BMI	30.89	30.41	0.79
Diabetes	0.14	0.15	0.98
American Society of Anesthesiology score	2.43	2.41	0.96
Stone size (mm)	4.57	6.00	0.03
Positive urine culture	0.71	0.56	0.45
Admission temperature (°C)	37.94	37.1	0.04
Admission heart rate	109.57	90.54	0.03
Admission respiratory rate	18.00	20.02	0.17
Admission WBC	15.53	15.33	0.95
Time to urology consult (hours)	3.66	8.27	0.0003
ICU admission	0.00	0.15	0.28
Step-down care	0.86	0.85	0.98
Hospital duration (hours)	35.62	71.6	0.01

Our findings suggesting improved health outcomes due to timely management of patients with obstructing urinary stones and concern for sepsis are consistent with other medical specialties. For example, current cardiothoracic surgery literature indicates that more timely surgical intervention to treat mitral regurgitation and infected aortic aneurysms improves patient outcomes.[8,9] In the urology literature, Blackwell et al. showed a benefit to timely decompressive intervention for obstructing urinary stones and sepsis leading to improved health outcomes.[5] However, this study considered timely intervention to be within 48 hours and primarily evaluated the concept of a ''weekend effect,'' whereas our study considers outcomes earlier in the episode of care. With the wealth of literature supporting the benefit of early intervention for all types of sepsis,[10] it is intuitive that early specialist consultation would be associated with improved outcomes. Indeed, our study indicates that delayed urologic consultation leads to delays in stent placement. This is consistent with published data indicating that the inability to access specialists leads to delays in acute stone treatment and results in less optimal health outcomes.[11,12]

Data presented in this study also provide an opportunity for quality improvement in the early care of patients with obstructing urinary stones and concern for sepsis. Clinical care pathways offer one such mechanism to address this issue. Establishment of an ED clinical care pathway in the management of acute asthma exacerbation resulted in decreased need for hospital admission in pediatric patients.[13] Similarly, clinical care pathways established for emergent care of patients with appendicitis have shortened time from the ED presentation to operative intervention and resulted in decreased subsequent complications.[14,15] Based on these data, it is reasonable to conclude that creation and adoption of such a pathway for management of obstructing urinary stones in patients with concern for sepsis would improve patient health outcomes.

Beyond its implications for patient health outcomes, our data also suggest an economic benefit to timely intervention.

It has been previously estimated that nephrolithiasis costs the health care system 5 billion dollars per year and more than doubles the annual health care expenditures for individuals with stone disease compared with those without such a claim. Much of this expense is due to hospitalization and acute care related to kidney stones. Moreover, economic analysis of kidney stone disease indicates that interventions targeted toward improvement in acute care of stone disease would be expected to decrease costs.[16]

Our results must be viewed in the context of several limitations. First, by utilizing the SIRS criteria, we were able to define patients in whom there was concern for systemic infection. However, recent data suggest that the SIRS criteria are not as sensitive for sepsis as newer measures such as the quick sepsis-related organ failure assessment (qSOFA), which is more predictive of sepsis and mortality.[17] This likely explains why only $\sim 50\%$ of our cohort had a demonstrable urinary source of infection. We chose to utilize the SIRS criteria for our analysis since its components are readily available during chart review, and it is still widely utilized for patient triage. Second, our sample size was relatively small owing to our selective patient criteria and single-institution nature of the study. What we lack in statistical power relative to other analyses performed using large administrative data sets we gain in remarkable granularity allowing us to evaluate precisely how early intervention impacts outcomes. For example, one such study demonstrates a large variety of more adverse outcomes following percutaneous nephrostomy *vs* competing treatments for early intervention, but due to its size is unable to capture disease severity via WBC count.[18] Therefore, this type of study is not only unable to determine timelier treatment window like ours, but also it is incapable of concluding the relative effectiveness of various treatments.

In addition, we recognize that criteria for safe discharge are subjective and may vary from one physician to the next. While our general departmental discharge guidelines are aligned across providers, this may contribute to confounding. Finally, we only examined ureteral stent placement as a means of renal decompression. While it is likely that similar findings would be seen with percutaneous renal drainage, this was not assessed in the current study.

Conclusion

Our findings indicate that timely ureteral stent placement in patients with obstructing urinary stones and concern for sepsis improves health outcome in the form of decreased LOS. Moreover, it suggests that delay in urologic consultation may be implicated as a causative factor and offers an opportunity for quality improvement. In the future, establishment of a clinical care pathway for these patients would be useful and its effects on patient outcomes could be evaluated in a prospective manner using a similar consult database. These data would certainly be of interest to providers and payors seeking to improve the overall quality of care for patients with kidney stones.

Author Disclosure Statement

C.A.D. is a consultant for Boston Scientific Corporation and has grant funding from Blue Cross Blue Shield of Michigan. K.R.G. is a consultant for Lumenis and has grant funding from Blue Cross Blue Shield and Boston Scientific.

References

1. Scales CD, Smith AC, Hanley JM, Saigal CS; Urologic Diseases in America Project. Prevalence of kidney stones in the United States. Eur Urol 2012;62:160–165.
2. Ordon M, Urbach D, Mamdani M, et al. The surgical management of kidney stone disease: A population based time series analysis. J Urol 2014;192:1450–1456.
3. Wagenlehner FME, Weidner W, Naber KG. Optimal management of urosepsis from the urological perspective. Int J Antimicrob Agents 2007;30:390–397.
4. Borofsky MS, Walter D, Shah O, et al. Surgical decompression is associated with decreased mortality in patients with sepsis and ureteral calculi. J Urol 2013;189:946–951.
5. Blackwell RH, Barton GJ, Kothari AN, et al. Early intervention during acute stone admissions: Revealing 'The Weekend Effect' in urological practice. J Urol 2016;196: 124–130.
6. Johnson EK, Filson CP, Faerber GJ, et al. Prospective tracking of pediatric urology consults: Knowing is half the battle. J Urol 2012;187:1844–1849.
7. Davenport DL, Bowe EA, Henderson WG, Khuri SF, Mentzer RM. National Surgical Quality Improvement Program (NSQIP) risk factors can be used to validate American Society of Anesthesiologists Physical Status Classification (ASA PS) levels. Ann Surg 2006;243:636–641–discussion 641–644.
8. Suri RM, Vanoverschelde JL, Grigioni F, et al. Association between early surgical intervention vs watchful waiting and outcomes for mitral regurgitation due to flail mitral valve leaflets. JAMA 2013;310:609–616.
9. Hsu R-B, Chen RJ, Wang S-S, Chu S-H. Infected aortic aneurysms: Clinical outcome and risk factor analysis. J Vasc Surg 2004;40:30–35.
10. Burrell AR, McLaws M-L, Fullick M, Sullivan RB, Sindhusake D. SEPSIS KILLS: Early intervention saves lives. Med J Aust 2016;204:73.e1–e7.
11. Odisho AY, Fradet V, Cooperberg MR, Ahmad AE, Carroll PR. Geographic distribution of urologists throughout the United States using a county level approach. J Urol 2009; 181:760–766.
12. Riddell AM, Charig MJ. A survey of current practice in out of hours percutaneous nephrostomy insertion in the United Kingdom. Clin Radiol 2002;57:1067–1069.
13. Bekmezian A, Fee C, Weber E. Clinical pathway improves pediatrics asthma management in the emergency department and reduces admissions. J Asthma 2015;52: 806–814.
14. Earley AS, Pryor JP, Kim PK, et al. An acute care surgery model improves outcomes in patients with appendicitis. Ann Surg 2006;244:498–504.
15. Ball CG, Dixon E, MacLean AR, et al. The impact of an acute care surgery clinical care pathway for suspected appendicitis on the use of CT in the emergency department. Can J Surg 2014;57:194–198.
16. Lotan Y. Economics and cost of care of stone disease. Adv Chronic Kidney Dis 2009;16:5–10.
17. Finkelsztein EJ, Jones DS, Ma KC, et al. Comparison of qSOFA and SIRS for predicting adverse outcomes of patients with suspicion of sepsis outside the intensive care unit. Crit Care 2017;21:73.

18. Sammon JD, Ghani KR, Karakiewicz PI, et al. Temporal trends, practice patterns, and treatment outcomes for infected upper urinary tract stones in the United States. Eur Urol 2013;64:85–92.

Address correspondence to:
Casey A. Dauw, MD
Department of Urology
University of Michigan
1500 E. Medical Center Drive
TC 3875, SPC 5330
Ann Arbor, MI 48109

E-mail: caseydau@med.umich.edu

Abbreviations Used

ASA = American Society of Anesthesiology
BMI = body mass index
CT = computed tomography
ED = emergency department
HR = heart rate
ICU = intensive care unit
LOS = length of stay
RR = respiratory rate
SIRS = systemic inflammatory response syndrome
T = temperature
WBC = white blood cell