Original Article

Current Urology

OPEN

Which objective emergency department parameters leads to expedited intervention in patients with acute urinary tract calculi

Zachary Kranz[a,*], Greggory Peifer[b], Matthew Rohloff[b], Thomas Maatman[b], Kenneth Shockley[b]

[a]Metro Health Hospital, Wyoming, MI, USA; [b]Urology, Metro Health Hospital, Wyoming, MI, USA

Abstract

Objectives: To retrospectively determine which objective measurements had an increased likelihood of requiring immediate surgical intervention in patients presenting to the emergency department (ED) with acute ureteral calculi.

Materials and methods: Employing our institution's electronic medical record system, we conducted a retrospective cohort study of 4366 patients who presented to the ED with an acute ureteral calculus over an 8-year period. Data consisting of relevant demographic information, vital signs, laboratory parameters, and interventional history was obtained and analyzed.

Results: This study consisted of 4366 patients presenting to the ED with acute ureteral calculi, of whom 312 (7%) required a procedure prior to being discharged. Of these 312 patients, 290 (6.6%) underwent cystoscopy with ureteral stent placement and 22 (0.5%) were sent to interventional radiology for percutaneous nephrostomy tube placement. Patients who tested positive for nitrites in their urine had a relative risk of 3.48 of receiving intervention when compared to the nitrite negative group.

Conclusions: Through this retrospective cohort study, we were able to find what objective measurements were associated with an increased need for immediate surgical intervention in patients who presented to the ED with acute ureteral calculi. With this data, urologists can be better equipped to identify the patients that present in the emergency setting that will require urgent intervention.

Keywords: Cystoscopy; Emergent surgical intervention; Objective measurements; Ureteral calculi; Urinary nitrates

1. Introduction

Urinary tract calculi lead to approximately 1.3 million emergency department (ED) visits per year.[1] Of these visits, the majority of patients are managed conservatively with adequate fluid intake and analgesics for pain management.[2] Complications of this management strategy can include nausea, vomiting, pain, infection, and acute kidney injury. Despite a majority of these patients being managed with medical expulsive therapy, a minority of these patients will require emergent intervention because the calculi are superimposed on an infection.

Current American Urologic Association guidelines recommend urgent renal decompression in patients who present with obstructing stones and concurrent suspected infection.[3] Without treatment, these patients are at risk of developing life-threatening obstruction-base sepsis. In fact, patients who do not receive treatment for their obstructing stone with urinary tract infection (UTI) and sepsis are more than twice as likely to die upon subsequent hospitalizations than patients who do receive surgical decompression.[4] Surgical renal decompression is typically completed via 2 separate techniques, ureteral stents or percutaneous nephrostomy tubes. These 2 treatment options have been found to be equally effective for the decompression of obstructed urinary tracts.[5] A lot of research has gone into attempting to appropriately diagnose and treat this particular subset of patients. The emergency ureteral stone treatment score created by Tran et al.[6] enables us to predict which patients will have successful treatment of their urinary tract calculi. In addition, the ureteral calculi urinary culture calculator created by Rohloff et al.[7] was established to help diagnose the probability of culture positivity in the setting of a ureteral calculus.

With these treatments available, the ED clinicians must first determine which patients require urgent/emergent renal decompression. It can be difficult for clinicians to quickly determine if there is a superimposed infection in patients who present to the ED with obstructive uropathy. With blood and urine cultures taking >24 hours to yield a definitive diagnosis, we rely heavily on clinical discretion to determine whether patients require emergent intervention. Lack of data on the clinical variables that are associated with the need for emergent intervention places a large burden on the diagnosing physicians.

The aim of the present study is to determine if there is an association between objective laboratory parameters or patient demographics and the likelihood requiring emergent intervention for patients presenting to the ED with acute urinary tract calculi.

2. Materials and methods

We conducted a retrospective cohort chart review using our institution's electronic medical record system after institutional review board approval was attained. The review collected data on

* *Corresponding Author: Zachary Kranz, DO, Ascension Macomb-Oakland, 27450 Schoenherr RD STE 400, Warren, MI 48088, USA. E-mail address: kranzzac@msu.edu (Z. Kranz).*

Current Urology, (2022) 16, 1–4

Received March 18, 2020; Accepted July 2, 2020.

http://dx.doi.org/10.1097/CU9.0000000000000070

common demographic information, including medical comorbidities, initial vital signs, laboratory parameters, and patient intervention in relations to their ureteral calculus.

In our institution's electronic medical record system, we searched for a diagnosis of ureteral calculi based on ICD 9 and ICD 10 codes from January 1, 2009 to August 1, 2017. Patients met the inclusion criteria if they had the diagnosis of ureteral calculi, had computed tomography (CT) documented ureteral calculi, were 18 years or older, and patient records were available through Electronic Privacy Information Center. Patients were excluded if they were missing any of the necessary demographic or laboratory data. A total of 4366 patients were eligible for analysis. For this study, hydronephrosis was defined by the anterior-posterior renal pelvic diameter.

Data was analyzed using means for continuous variables and percentages for categorical variables. Relative risk and changes to risk were used to further examine categorical variables. Statistical significance using analysis of variance was calculated based on the means from the three different patient procedural groups: patients who underwent no intervention, patients who underwent cystoscopy with ureteral stent placement, and patients who underwent interventional radiology percutaneous nephrostomy (IR PCN) tube placement. Statistical significance of the other means was determined using the *t*-test. A p value of <0.05 was deemed significant for both statistical analysis methods.

The primary endpoint of this study was to determine which objective laboratory measurements in patients presenting to the ED in the setting of an acute urinary tract calculi prompted urgent/emergent intervention.

3. Results

Of the 4366 patients included in this study, 4054 (93%) required no intervention and 312 (7%) required an interventional procedure prior to being discharged home. Interventions consisted of cystoscopy with ureteral stent placement in 290 (6.60%) patients and IR PCN tube placement in 22 (0.50%) patients. Within 12 hours of presentation to the ED (day 0), 152 (3.48%) patients underwent cystoscopy and 11 (0.25%) patients underwent IR PCN tube placement. Between 12 and 24 hours after presentation to the ED (day 1), 138 (3.16%) patients underwent cystoscopy and 11 (0.25%) patients underwent IR PCN tube placement. Pregnant women represented a minority of females in the cohort.

As shown in Table 1, statistically significant differences existed in patient demographics, vital signs, and laboratory values between the means of patients who required intervention and those who did not require intervention. Patient age, heart rate, temperature, serum white blood cell (WBC) count, and serum creatinine were all elevated in patients who received intervention in comparison to patients who received no intervention. The serum WBC count was significantly higher in the intervention positive group with a mean of 12.93 versus $10.2 \times 10^3/\mu L$ in the intervention negative group ($p < 0.001$).

Table 2 shows the objective measurements obtained depending on the type of intervention that the patient received. Patient age, heart rate, serum WBC count, serum creatinine, and serum percentage of polymorphonuclear neutrophils (PMNs) were found to all be highest in patients who received IR PCN. Excluding heart rate, these same parameters were elevated in patients who received cystoscopy, compared to patients who received no intervention. Results showed serum WBC count was highest in patients who received IR PCN with a mean of 14.16 versus $12.83 \times 10^3/\mu L$ in patients who received cystoscopy versus $10.20 \times 10^3/\mu L$ in patients who received no intervention ($p < 0.001$). Blood pressure was lowest in patients who received IR PCN with a mean of 127/76 versus 143/84 mm Hg in patients who received cystoscopy versus 146/89 mm Hg in patients who received no intervention ($p < 0.001$).

Table 3 illustrates the differences in mean laboratory parameters, vital signs, and patient demographics between patients who received interventional therapy on day 0 versus day 1. Serum WBC count was higher in patients who received intervention on day 0 with a mean of 12.88 versus $10.28 \times 10^3/\mu L$ in patients who received intervention on day 1 ($p < 0.001$). Serum PMN percentage was also increased in patients who received intervention on day 0 with a mean of 77.63% versus 69.20% in patients who received intervention on day 1 ($p < 0.001$). Age, heart rate, temperature, and serum creatinine were similarly elevated in patients who received intervention on day 0.

Table 4 shows the relative risk patients had of receiving interventional therapy for acute urinary tract calculi. Mild elevated relative risks were seen in Caucasians (1.35), females (1.47), and patients with diabetes (1.65). Compared to those who tested negative for nitrites on urinalysis, patients with a positive

Table 1

Mean objective measurements in patients with versus without intervention

Variables	Intervention	No intervention	*p*
Age, yr	52.5	44.3	<0.001
Heart rate, beats per minute	83.4	78.8	<0.001
Temperature, °C	36.91	36.68	<0.001
White blood cell, $10^3/\mu L$	12.93	10.2	<0.001
Creatinine, mg/dL	1.5	1.1	<0.001

Table 2

Mean objective measurements in patients with different types of intervention

Variables	Cystoscopy	IR PCN	None	*p*
Age, yr	51.69	59.18	44.27	<0.001
Heart rate, beats per minute	81.64	106.90	81.64	<0.001
WBC, $10^3/\mu L$	12.83	14.16	10.20	<0.001
Creatinine, mg/dL	1.48	1.90	1.10	<0.001
PMN, %	76.40	81.50	69.04	<0.001
Blood pressure, mm Hg	143/84	127/76	146/89	<0.001

IR PCN = interventional radiology percutaneous nephrostomy; PMN = polymorphonuclear neutrophils; WBC = white blood cell.

Table 3

Mean objective measurements based on day of intervention

Variables	Day 0	Day 1	*p*
Age, yr	51.29	44.52	<0.001
Heart rate, beats per minute	82.40	79.15	0.006
Temperature, °C	36.84	36.69	0.001
WBC, $10^3/\mu L$	12.88	10.28	<0.001
Creatinine, mg/dL	1.49	1.11	<0.001
PMN, %	77.63	69.20	<0.001

PMN = polymorphonuclear neutrophils; WBC = white blood cell.

Table 4
Patient demographic and laboratory parameters relative risk data

	Variable 1	Intervention %	Variable 2	Intervention %	Risk % increase	Relative risk
Race	Caucasian	7.4	Non-Caucasian	5.5	1.9	1.35
Sex	Female	8.9	Male	5.8	3.1	1.53
Diabetic	Yes	11.4	No	6.9	4.5	1.65
Nitrites in urine	+	22.3	−	6.4	15.9	3.48

nitrite status had a relative risk of 3.48 of receiving interventional therapy.

4. Discussion

Approximately 1 in 11 citizens of the United States reports a history of nephrolithiasis.[8] This is increased to 1 in 5 in high risk patient groups.[8] These calculi can be superimposed on an infection, placing patients at risk for urosepsis if decompression is not obtained. Urine and blood cultures can take >24 hours to yield a definitive diagnosis forcing physicians to rely on clinical discretion to determine whether patients require emergent intervention or not.

Patients presenting to the ED with signs and symptoms of acute ureteral calculi should receive a basic work-up that includes vital signs, urinalysis, and laboratory panels. We identified that age, heart rate, temperature, WBC count, and serum creatinine levels were statistically significant in the determination of a patient receiving emergent intervention (Table 1); however, the clinical significance of the difference in temperature is uncertain. It would be difficult to conclude the need for emergent intervention based on a temperature difference of 0.23°C. Conversely, age difference was found to be statistically significant and has its clinical significance confirmed through a study conducted by Krambeck et al.,[9] where they found that as patients age, they are more likely to have concurrent UTIs and require surgical intervention. In the present study, we identified that patients who are in their 5th decade of life are at a greater risk of receiving interventional treatment compared to patients in their 4th decade of life. We also discovered that laboratory values had clinical and statistical significance. The WBC count in patients who received emergent intervention was found to be 12.93 versus $10.2 \times 10^3/\mu L$ in patients who received no emergent intervention. This difference of $2.7 \times 10^3/\mu L$ is of clinical significance because the serum WBC count of $12.93 \times 10^3/\mu L$ fulfills one of criteria for the Systemic Inflammatory Response Syndrome criteria (body temperature >38°C or <36°C, respiratory rate >20 breaths per minute, heart rate >90 bpm, and WBC count >12,000/mL or <4000/mL).[10] Serum creatinine has been found to have a reference of 0.55–1.02 mg/dL for females and 0.72–1.18 mg/dL for males.[11] In patients who received emergent intervention, serum creatinine was found to be elevated outside of these reference ranges.

Cystoscopy with ureteral stent placement and IR PCN are both options used as interventions for the treatment of infected urinary tract calculi. When comparing intervention options, we found statistically significant differences in patient demographics, vital signs, and laboratory parameters between patients who received cystoscopy, IR PCN, and no intervention (Table 2). Although blood pressure was found to be statistically significant, its clinical significance is uncertain. The blood pressures in patients who received cystoscopy (143/84 mm Hg), IR PCN (127/76 mm Hg) and no intervention (146/89 mm Hg) are all values commonly seen in patients presenting to the ED. Heart rate was increased in patient who received IR PCN (106.9 bpm) when compared to patients who received either cystoscopy or no intervention (81.64 and 81.64 bpm, respectively). This elevated heart rate was found to be statistically significant and is clinically significant as tachycardia is a part of the systemic response to infection and is one of the objective signs seen in sepsis.[12] For patients receiving IR PCN, this pattern of elevated values was also seen in serum WBC counts, creatinine levels, and PMN count. These results are corroborated by a study done by Goldsmith et al.[13] where they found that, compared to cystoscopy with stent placement, IR PCN is utilized in patients who present as more acutely ill and with larger urinary tract calculi.

Of the 4366 patients included in this study, 163 patients received an interventional treatment within 12 hours of presenting to the ED. As shown by Table 3, the patients who received interventional treatment on day 0 had a statistically significant elevated mean age, laboratory parameters, and vital signs compared to patients who received interventional treatment on day 1. The clinical significance of the difference in temperature is uncertain as it is difficult to extrapolate the need for urgent intervention based on a difference of 0.15°C. Of the values that were increased, serum WBC count and serum PMN count may be the two most indicative of an acute infection and consequential need for urgent intervention. The results of the differences in age, WBC count, serum creatinine levels, and PMN count further corroborate the idea that these values can help physicians determine the patients who will require emergent intervention for their acute urinary calculus.

Urinary nitrites measure the presence of Gram-negative organisms in the urinary system, with the most common etiology secondary to UTIs. Urinary nitrites are suggestive of a UTI with a specificity of 98% and a positive predictive value of 96%.[14] We found that compared to nitrite negative urine, patients who tested positive for nitrites in their urine had a relative risk of 3.48 of receiving interventional treatment (Table 4). Of the observed variables, urinary nitrites were found to be the highest risk factor for receiving interventional treatment. The results of Table 4 suggest that while race, sex, and diabetic status can affect the decision of physicians to initiate interventional therapy, nitrites in the urine, and their association with UTIs, are the most important variable in this decision.

This study has limitations with the first being that it was a retrospective study. As a retrospective study, this study was inherently flawed by the lack of control we had on possible confounding variables. For instance, we were unable to control for other sources of infection or inflammation that could have led to elevated WBC counts, PMN count, and vital signs. Other sources of infection or inflammation superimposed on urinary tract calculi could have led to increased suspicion that emergent

intervention was needed. With this being a retrospective nature of this study, we were unable to determine the number of patients with a congenital renal anomaly, and thus patients with an innate increased risk of renal calculi. Another constraint of this study is the subjective nature by which physicians decided which patients required emergent intervention. This could have resulted in inconsistencies between physicians on what criteria they decided was indicative of requiring emergent intervention. At our institution it is not standard to get kidney, ureter, and bladder studies to analyze renal calculi if a CT scan was already performed, which our cohort of patients all had CT scan documented ureteral calculi. Nor is it standard of care to get genetic analysis of patients presenting to the ED with renal calculi. Also, we did not have access to the stones composition because often times we had no specimen to analyze with most stones being dusted or only a ureteral stent being placed. These limited our ability to classify the renal calculi by etiology or composition. A prospectively designed study is required to validate these objective parameters as being effective for determining which patients with acute urinary calculi require emergent intervention. This would allow for the control of confounding variables and decrease the subjective nature by which physicians make this decision.

Despite the limitations to this study, a population size of 4366 patients provides a high statistical significance to the results of the study. Also, this study observes objective measurements to construct conclusions. Finally, the community setting of our institution allows for the generalization of our results to the community-based institutions.

Clinical knowledge and understanding of laboratory values and patient demographics can be used by physicians to help quickly determine which patients require urgent/emergent stone intervention. Risk factors for such intervention include tachycardia, elevated serum creatinine, elevated PMN count, white race, female sex, diabetics and nitrite positive urine. With this data, urologists can be better equipped to identify the patients that present in the emergency setting that will require urgent intervention.

Acknowledgments

None.

Statement of ethics

This study was approved by institutional review board of Metro Health, with an approval number 2019002. Waive of consent/HIPPA was authorized as the study was retrospective in nature and the planned volume of patients' charts to be reviewed would have made consenting each one infeasible. All procedures performed in study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

Funding source

None.

Author contributions

All authors contributed equally in this study.

References

[1] Foster G, Stocks C, Borofsky MS. Emergency department visits and hospital admissions for kidney stone disease, 2009: Statistical brief. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (MD): Agency for Healthcare Research and Quality (US); 2012:139.
[2] Parmar MS. Kidney stones. *BMJ* 2004;328(7453):1420–1424.
[3] Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American Urological Association/Endourological Society Guideline. *J Urol* 2016;196(4):1153–1169.
[4] Borofsky MS, Walter D, Shah O, Goldfarb DS, Mues AC, Makarov DV. Surgical decompression is associated with decreased mortality in patients with sepsis and ureteral calculi. *J Urol* 2013;189(3):946–951.
[5] Pearle MS, Pierce HL, Miller GL, et al. Optimal method of urgent decompression of the collecting system for obstruction and infection due to ureteral calculi. *J Urol* 1998;160(4):1260–1264.
[6] Tran TY, Hernandez Bustos N, Kambadakone A, Eisner B, Pareek G. Emergency ureteral stone treatment score predicts outcomes of ureteroscopic intervention in acute obstructive uropathy secondary to urolithiasis. *J Endourol* 2017;31(9):829–834.
[7] Rohloff M, Shakuri-Rad J, McElrath C, et al. Which objective parameters are associated with a positive urine culture in the setting of ureteral calculi: The ureteral calculi urinary culture calculator. *J Endourol* 2018;32(12):1168–1172.
[8] Scales CDJr, Smith AC, Hanley JM, Saigal CS. Prevalence of kidney stones in the United States. *Eur Urol* 2012;62(1):160–165.
[9] Krambeck AE, Lieske JC, Li X, Bergstralh EJ, Melton LJ3rd, Rule AD. Effect of age on the clinical presentation of incident symptomatic urolithiasis in the general population. *J Urol* 2013;189(1):158–164.
[10] Bone RC, Balk RA, Cerra FB, et al. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. *Chest* 1992;101(6):1644–1655.
[11] Ceriotti F, Boyd JC, Klein G, et al. Reference intervals for serum creatinine concentrations: Assessment of available data for global application. *Clin Chem* 2008;54(3):559–566.
[12] Bone RC. Gram-negative sepsis. Background, clinical features, and intervention. *Chest* 1991;100(3):802–808.
[13] Goldsmith ZG, Oredein-McCoy O, Gerber L, et al. Emergent ureteric stent vs percutaneous nephrostomy for obstructive urolithiasis with sepsis: Patterns of use and outcomes from a 15-year experience. *BJU Int* 2013;112(2):E122–128.
[14] Koeijers JJ, Kessels AG, Nus S, et al. Evaluation of the nitrite and leukocyte esterase activity tests for the diagnosis of acute symptomatic urinary tract infection in men. *Clin Infect Dis* 2007;45(7):894–896.

How to cite this article: Kranz Z, Peifer G, Rohloff M, Maatman T, Shockley K. Which objective emergency department parameters leads to expedited intervention in patients with acute urinary tract calculi. *Curr Urol* 2022;16(1):1–4. doi: 10.1097/CU9.0000000000000070