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ORIGINAL CLINICAL ARTICLE

Outcomes of renal calculi in patients with spinal cord injury

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Abstract

Aims: Patients with spinal cord injury (SCI) are at risk of developing renal calculi. This study describes the management of renal calculi among patients with SCI with attention to factors influencing surgical management vs observation.

Methods: This retrospective, cohort study identified patients with SCI and renal calculi between 2009 to 2016 from an institutional neurogenic bladder database and detailed the management of their stones. A stone episode was defined as radiographic evidence of new calculi.

Results: Of 205 patients with SCI, 34 had renal stones, for a prevalence of 17%. The mean age was 50 years (range 22,77) and most had cervical SCI (n = 22, 65%). There were 41 stone episodes with 98 individual stones identified with a mean stone size of 4.9 mm (range 1-19).

Of the 41 episodes, 10 (24%) underwent surgery after initial diagnosis. Pain was the most common primary indication for surgery (n = 9, 60%). The median time from diagnosis to intervention for all patients was 4 months (interquartile range 1,23). Of the 41 episodes, 31 (76%) were initially observed and among these, 5 ultimately required surgery (16%) while 26 (84%) did not. Of these 26, 12 (46%) stones passed spontaneously and 14 (53%) remained unchanged. The need for surgery correlated with more stone episodes ($P = .049$).

Conclusion: In this cohort of patients with SCI and small, nonobstructing renal stones, 76% (n = 31) were offered observation. Of these observed patients, 84% (n = 26) did not require further intervention at a median of 4 years of follow-up.

KEYWORDS
endourology, neurogenic bladder, spinal cord injury, stones, urolithiasis

1 | INTRODUCTION

In the mid-20th century, it was said that stone formation was a great menace to the urinary tract in patients with neurogenic bladder.[1] In fact, between 1944 and 1969, urogenital disease consisting of infections and renal failure was the most common cause of death among patients with spinal cord injury (SCI), accounting for nearly 1/3 of deaths.[2] Fortunately, the contemporary management of neurogenic bladder has led to improvements in the urogenital care of patients with SCI. Now, the urogenital disease accounts for less than 10% of death, representing the 4th cause of mortality since 1990.[3,4] Recent estimates report that patients who survive the first 3 years after SCI, will have between 48% and 84% of the average normal life expectancy, depending on the level of their SCI.[4]

The combination of urinary stasis, prolonged immobility leading to resorptive hypercalciuria, and urinary tract bacterial colonization with protease splitting organisms places patients with SCI at increased risk of urinary calculi formation.[5,6] Their risk of stone formation is about 6 times greater than the general population.[7]

The Consortium for Spinal Cord Medicine Guidelines for Bladder Management for Adults and the European Association of Urology (EAU) Guidelines on Neurogenic Bladder recommend urologic evaluation annually with upper tract imaging every 6 to 12 months.[8,9] This surveillance imaging can lead to a finding of asymptomatic calculi. However, there are currently no published guidelines regarding the management of incidentally found renal calculi in patients with SCI.

A study from our institution of 46 consecutive patients with SCI undergoing ureteroscopy found that 21% of patients suffered a perioperative complication.[5] Furthermore, achieving stone-free status in this population with minimally invasive surgery was challenging, and in this study was reported in only 17% of patients.[5]

This current study aims to describe the management of renal stones among patients with SCI at a tertiary care center. Specifically, risk factors influencing surgical vs conservative management of calculi will be described.

2 | METHODS

Institutional review board approval was obtained for this study (HUM 00031859). A prospectively maintained institutional neurogenic bladder database was queried to identify patients with SCI and history of renal or ureteral calculi from 9/2009 until 12/2016. Demographic data and clinical data pertinent to SCI, neurogenic bladder, and urolithiasis diagnosis were retrieved from the database.

Only patients with neurogenic bladder secondary to SCI (traumatic or medical) were included. Spinal cord injuries due to spinal tumors and transverse myelitis were included in the population. Other causes of neurogenic bladder, such as multiple sclerosis, myelomeningocele, cerebral palsy, sacral agenesis, pelvic nerve injury, brain injury or systemic neurologic disease were excluded. Furthermore, only renal calculi were included; ureteral calculi and bladder calculi were excluded. A stone episode was defined as radiographic evidence of a new calculi(us) discovered by ultrasound (US) or computed tomography (CT) obtained either for routine screening, incidentally on imaging for other causes or for patient symptoms. In this population, routine upper tract surveillance with renal ultrasound is performed annually. Indications for surgical intervention in this cohort follow the 2018 European Association of Urology and the 2016 American Urological Association (AUA) guidelines.[10,11] These include stone growth, stones in high-risk patients for ongoing formation, obstruction, infection, stones >15 mm, and patient preferences. Patients who do not meet these criteria, qualify as meeting the basic safety parameters for observation.

Descriptive statistics were utilized to evaluate the population. For normally distributed data, mean and standard deviations are reported, otherwise, medians with interquartile ranges (Q1, Q3) are shown. Subgroups based on demographic or clinical variables were evaluated and compared utilizing inferential statistics. For normally distributed data, *t* test and analysis of variance were utilized to compare continuous variables and the chi-squared test was utilized to compare categorical variables. Fischer's exact test was utilized if there were less than 5 values within a group. For data that were not normally distributed, nonparametric tests were utilized. The level of significance was set at $P < .05$. IBM SPSS® Statistics version 25 was utilized for statistical analysis

3 | RESULTS

Of 315 patients within the neurogenic bladder database, 205 had SCI (190 traumatic or medical SCI, 9 transverse myelitis, and 6 spinal tumors). Of these, 144 patients had no stones on imaging, 25 patients had no imaging, and 36 patients had confirmed stones, 2 patients with ureteral stones were excluded. Of the 34 patients with renal stones, the mean age was 50 years (range 22-77) (Table 1). Patients sustained their SCI at a median age of 26 years old (interquartile range [IQR] 16,43) (Table 1). The median length of follow-up following the patient's first stone episode was 4 years (IQR 2,6) (Table 2). The majority of patients were male and Caucasian with cervical SCI and ASIA A classification (Table 1). Over half of the patients (n = 19, 56%) managed their bladder with intermittent catheterization, whereas the remaining half were divided between urinary diversion (n = 7, 21%) and suprapubic tube (n = 6, 19 = 18%) (Table 1).

TABLE 1 Patient characteristics

	Number (n = 34)	%
Current age (mean, range)	50 (22-77)	
Age at spinal cord injury (SCI) (median, IQR)	26 (16,43)	
Gender: Male	26	77
Race: Caucasian	33	97
Level of SCI		
Cervical	22	65
Thoracic	7	21
Lumbar	5	15
ASIA classification		
A	17	50
B	3	9
C	3	9
D	4	12
Unknown	7	21
Comorbidities		
Pulmonary disease	10	29
Cardiac disease	13	38
Diabetes mellitus	2	6
Chronic kidney disease	2	6
Venous thromboembolism	9	26
Bladder management		
Voiding	2	6
Intermittent catheterization	19	56
Suprapubic tube	6	18
Urinary diversion	7	21

Abbreviation: IQR, interquartile range.

A total of 98 stones were identified in these 34 patients with 41 stone episodes and a median of 2.5 stones per episode (IQR 1,4) (Table 2). Most patients had only one stone episode (n = 29), several had multiple, including one patient with five episodes. The presence of stones was most commonly diagnosed by CT (n = 19, 46%) and renal ultrasound (n = 19, 46%). Imaging was obtained for neurogenic bladder surveillance in 49% (n = 20), genitourinary symptoms (renal colic) in 39% (n = 16), and non-urologic symptoms in 12% (n = 5). As expected, imaging for neurogenic bladder follow-up was more commonly US than CT (n = 14 vs 4, $P = .12$) (Table 3).

Out of each of the 98 stones identified, the mean maximum stone diameter was 4.9 mm (range 1-19 mm). Stone laterality was equally distributed between kidneys (49% right, 51% left). However, there was a disproportionate amount of stone burden located at the lower pole (n = 60, 61%). Four stones (3 episodes) were located at the ureteropelvic junction (Figure 1).

In the 41 episodes, 4 (10%) patients underwent immediate surgery (within 4 weeks) and 6 (15%) underwent early surgery (within 12 months). The most common indication for surgery in these 10 episodes was flank or abdominal pain (n = 5) and infection occurred only in 1 patient. The remaining 31 (75%) episodes were initially managed with observation, and of these, 5 (16%) ultimately required intervention at a median of 44 months (IQR 19, 67) after discovery. Reasons for surgery in these five included flank or abdominal pain (n = 4) and infection requiring hospitalization (n = 1). For the 26 (84%) episodes that continued on observation, 12 (39%) resolved with spontaneous stone passage, while stones in the remaining 14 (45%) episodes were unchanged (Figure 2).

TABLE 2 Relationship between patient demographics and stone formation

		IQR	
	Median	Q1	Q3
Age at first stone, y	47	34	58
Time between SCI and stone, y	7.5	3	29
Total no. stones per patient	2.5	1	4
Total follow-up time, y	4	2	6

Abbreviation: IQR, interquartile range; SCI, spinal cord injury.

Of the 34 patients, who had a total of 41 stone episodes, 14 (41%) patients underwent surgical intervention for renal calculi (one patient had two surgeries for two separate stone episodes). Of the surgical interventions performed, ureteroscopy was the most common procedure (n = 10, 63% of all procedure) followed by percutaneous nephrolithotomy (n = 3, 7%) (Figure 2).

There was no relationship between the mean number of stones and demographics or bladder management modality. Nor was there an association between a total number of stones and age at SCI ($P = .88$) or age at first intervention for nephrolithiasis ($P = .33$) (Table S1). Subgroup analysis to evaluate which patients had risk factors for intervention revealed that patients undergoing surgery had more stone episodes ($P = .049$) than the observed group. However, we did not find that the level of SCI or ASIA classification was associated with whether patients developed a symptomatic stone ($P = .209$ and $P = .780$, respectively). Furthermore, spontaneous stone passage was not correlated to stone diameter ($P = .26$), laterality ($P = .09$), or location ($P = .65$).

TABLE 3 Indications for imaging for each episode (n = 41)

	N	%
Neurogenic bladder screening	20	49
Genitourinary symptoms (flank pain, UTI)	16	39
Non-GU symptoms	5	12

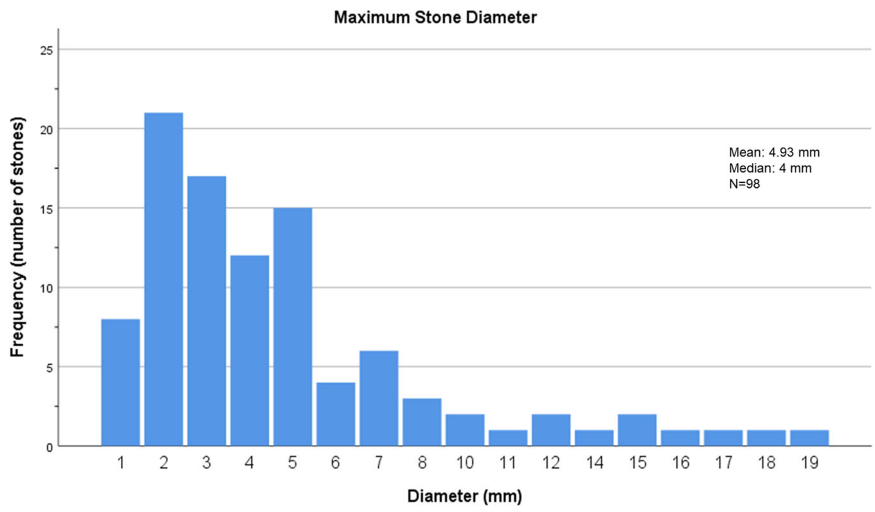

FIGURE 1 Stone diameter and frequency

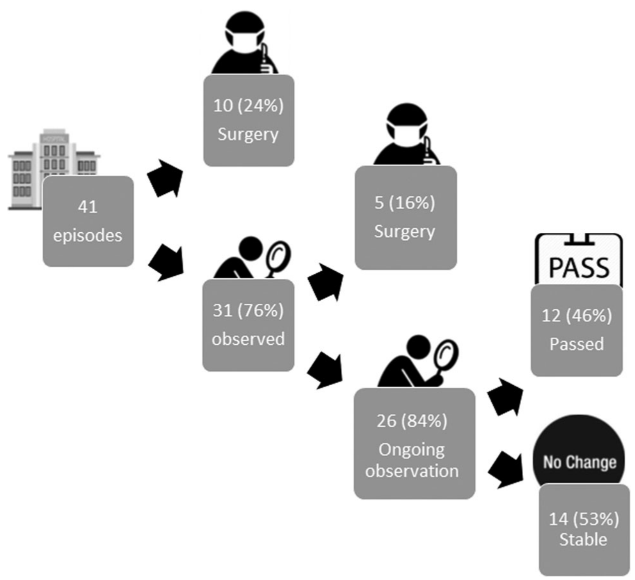

FIGURE 2 Flow chart of patient management

4 | DISCUSSION

In this cohort, 31 of the 41 renal stone episodes (76%) in patients with SCI were offered an initial observation. These were small (mean 4.9 mm, range 1-19 mm), nonobstructing renal stones on imaging. Of these 31 episodes initially observed, only 5 (16%) went on to require surgical intervention, whereas the remaining 26 (84%) episodes did not require intervention at a median follow-up of 4 years. While the outcomes of surgical interventions for nephrolithiasis in patients with SCI have been described,[5,12-15] to our knowledge no prior study has described the clinical outcomes of observed calculi among patients with SCI. In 2002, Chen described 77 patients with SCI and renal stones, and within that cohort 60 patients underwent conservative therapy with an 82% stone-free rate.[16] However, the rate of failure of conservative therapy (need for surgery) remained unknown. Understanding the natural history of nephrolithiasis in patients with SCI is paramount to informed decision making. This is because patients with SCI are at increased odds of developing major and minor complications after surgery for nephrolithiasis. Therefore, it is important to discuss observation as an option.[12,17] For example, the rate of complications for ureteroscopy and PCNL in patients with neurogenic bladder ranges from 12% to 21%.[5,6] Prior studies have proposed that observation of recalcitrant stones in compliant patients could be a reasonable approach to decrease morbidity associated with surgical intervention.[5]

Our data suggest that observation of renal stones in patients with SCI is a reasonable option in motivated patients who are well informed of their stone status and have no symptoms, infection, renal dysfunction and have small stones (mean 4.9 mm). Our data also suggests that only a minority of stones eventually require intervention since many pass spontaneously without symptoms or remain indolent.

Both AUA and EAU guidelines advocate for conservative management in patients with asymptomatic, nonobstructing renal stones.[10,11] In renal stones, the indications for surgical removal include stone growth, stones in high-risk patients for ongoing formation, obstruction, infection, stones >15 mm, and patient preferences.[10,11] It is important to note that our findings apply only to patients with small (mean 4.9 mm), nonobstructing renal stones, who do not meet indications for surgical removal as defined by these guidelines. For example, in our study, 10 (24%) stone episodes underwent immediate or early surgery since they did not meet these parameters. Our practice remains to obtain upper tract surveillance imaging every 12 months with renal ultrasound, and if small, incidental, nonobstructing, renal stones are identified, observation is offered to patients who meet these established criteria.

In this cohort, the majority of stones were small (mean 4.9 mm), lower pole stones (60%). In a retrospective study of 160 renal stones, Dropkin reported that overall the majority of stones (72%) remained asymptomatic over 3 years of follow-up.[18] The authors also found that lower pole stones were less likely than upper pole stones to become symptomatic.[18] It is important to note that there were three stones that did cause a painless, silent obstruction in their cohort. The safety of observation compared to surgical intervention for small renal stones was also studied in a trial of 150 patients randomized to observation, ureteroscopy, or shock wave lithotripsy.[19] In this study, 44 of the 50 patients that were randomized to observation either passed their stone or the stone remained unchanged.[19] The remaining 6 (12%) patients required surgical intervention for the development of symptoms or stone growth.[19] The rate of failing observation (requiring surgery), 12%, was within the range of the rate of complications in the surgical groups (6% to 14%).[19] Accordingly, the authors found that the success rates (noneventful ratio) ($P = .80$) and complication rates ($P = .56$) among the groups were similar.[19]

The prevalence of renal calculi among patients with SCI in our neurogenic bladder database was 16.6% (34/205). This rate fits within the range of previously published literature, (1.3% to 28%).[7,20,21] This literature however, was published between 1984-2007, since that time, diagnostic imaging has improved significantly and in our study, 46% of stones were diagnosed by CT, which has been demonstrated to be a more sensitive imaging tool than US or plain film.[22] In 2000, a study of over 8000 patients with SCI found that 3% of patients suffered from kidney stones with an average of 13 years follow-up after injury.[21] The same study predicted that within 10 years of SCI, 7% of patients would develop a kidney stone.[21] Kidney stone formation appears to be highest within 3 months of SCI (31 cases per 1000 person-years) and then reduces to 8 cases per 1000 after 8 years following SCI.[21] In our study, the median time between SCI and the first stone was 8 years (IQR 3,30), which aligns with this prior literature.[21]

While the data utilized for this current study was kept as a prospectively curated database, the study is limited due to its retrospective nature and small cohort. Only health information available within the neurogenic bladder database and the institutional electronic medical record was included. This could have led to under-reporting of surgical interventions if patients sought treatment at outside institutions. In addition, patients with stones identified on renal ultrasound who elected for observation did not routinely receive a confirmatory CT scan. Therefore, the incidence of stone can be overestimated by false positive renal ultrasounds. As part of this study, we did not collect information on adverse events, surgical outcomes nor on stone composition, all of which would be helpful to note when discussing options for management of calculi in patients with SCI.

5 | CONCLUSIONS

In this cohort of patients with SCI and small (mean 4.9 mm), nonobstructing renal stones, 76% (n = 31) were offered an observation based on established criteria. Of these observed patients, 84% (n = 26) did not require further intervention at a median of 4 years of follow-up. Future prospective studies focused on the adverse effects of observation as compared to surgical intervention are necessary.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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