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ARTICLE

Outcomes following surgical management of urinary stone disease in older patients

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Background: *The prevalence of urinary stone disease (USD) is increasing among older patients. Data examining the association between patient age and clinical outcomes following surgical treatment for USD are limited. Our objective was to assess the safety profiles of ureteroscopy (URS), extracorporeal shock wave lithotripsy (ESWL), and percutaneous nephrolithotomy (PCNL) for USD by age in an older patient population.*
Methods: *We retrospectively identified all patients who underwent URS, ESWL, and PCNL for USD from 2010 to 2019 in the Veterans Health Administration. We fit multivariable logistic regression models to determine the association between age and post-procedure sepsis, hospital readmission, and all-cause mortality within 30 days of admission.*
Results: *We identified 50,519 procedures for USD, including 41,216 URS (81.6%), 5741 ESWL (11.4%), and 3562 PCNL (7.1%). Overall, increasing age was associated with post-operative sepsis (aOR per five-year increase 1.02; 95% CI: 1.00–1.05), hospital readmission (aOR = 1.02, 95% CI: 1.01–1.04), and all-cause mortality within 30 days (aOR = 1.19, 95% CI: 1.10–1.29). Among URS cases, increasing age was significantly associated with sepsis (aOR = 1.03, 95% CI: 1.00–1.05), hospital readmission (aOR = 1.03, 95% CI: 1.01–1.05), and all-cause mortality (aOR = 1.19, 95% CI: 1.09–1.30) within 30 days. We detected no association between increasing age and adverse outcomes following ESWL or PCNL. Limitations include a lack of data on the type of stone disease and analysis of predominantly older male veterans, potentially limiting generalizability.*
Conclusions: *Following URS, age was independently associated with sepsis, hospital readmission, and all-cause mortality within 30 days of admission. This association was not found in patients who underwent ESWL or PCNL. Additional preoperative risk counseling and medical optimization may be beneficial in older patients undergoing URS.*

Key Words: 30-day complications, urolithiasis, old age, VHA, multivariable modeling

Introduction

Urinary stone disease (USD) affects approximately one in eleven individuals worldwide.[1] In the United States, the incidence of USD and the average age of patients with incident stone episodes have been increasing.[2] The greater burden of USD in an older patient population can be attributed to various behaviors (limited mobility, reduced fluid intake), increasing prevalence of comorbidities and urinary stone disease risk factors (obesity, hypertension, diabetes mellitus, recurrent urinary tract infections), and/or use of medications that promote stone formation.[3] As longevity increases, the prevalence of USD among the older population is expected to

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continue to rise, which imposes considerable risk to patients requiring surgical intervention.

Common surgical techniques for the management of USD are ureteroscopy (URS), extracorporeal shock wave lithotripsy (ESWL), or percutaneous nephrolithotomy (PCNL). URS is regarded as a first-line treatment for renal stones less than 20 mm.[4] URS has a high stone-free rate and a favorable safety profile.[4,5] ESWL has less morbidity and lower complication rates, but compared with URS, it has a higher recurrence rate.[4] PCNL is the first-line treatment for renal stones larger than 20 mm; however, it is associated with greater morbidity and risk of complications.[4] For older patients with more comorbidities and lower functional status, selecting the most appropriate surgical approach can minimize perioperative morbidity and mortality.[6] Though many studies have demonstrated acceptable safety of URS, ESWL, and PCNL in older patients, these studies are commonly limited by smaller sample sizes, report outcomes from a single institution, and lack post-discharge outcomes, which may fall short of detecting complications that occur later in the post-operative course.

Non-operative management can be a reasonable alternative in older, asymptomatic patients; however, the presence of ureteral obstruction, uncontrolled pain, declining kidney function, and recurrent urinary infections may lead patients and clinicians to consider surgical intervention. As such, the importance of assessing clinical outcomes following URS, ESWL, and PCNL in older patients cannot be understated. There is also a paucity of high-quality evidence regarding the safety profile of USD treatment modalities in older patient populations. In this study, we used a large national cohort of Veterans receiving care from the Veterans Health Administration (VHA) to assess clinical outcomes-sepsis, hospital readmission, and all-cause mortality-as well as associated risk factors in the 30 days following URS, ESWL, and PCNL.

Methods

Data source

We conducted a retrospective review of all patients who underwent URS, ESWL, and PCNL for USD in the VHA system from 2010 to 2019. VHA data were reported from the Veterans Affairs Surgical Quality Improvement Program, a database of 30-day surgical outcomes. Cases are systematically sampled from over 100 participating hospitals, and structured chart abstraction is performed by trained surgical quality nurses. Figure 1 shows the inclusion and exclusion criteria. We included patients with a diagnosis of renal or ureteral stones who had a Current Procedural Terminology code matching URS, ESWL, or PCNL procedures. For each patient, we considered only the first surgery within the study period, defined as the index procedure. For patients with procedure codes for multiple procedures on the same date, we assigned them to PCNL if one of their procedures was a PCNL, and assigned them to URS if they underwent a URS and ESWL. We excluded patients with a prior diagnosis or procedure for upper tract urothelial carcinoma, to exclude patients not undergoing URS for laser lithotripsy or a prior stone surgery within 12 months of the index surgery date, and to exclude second-look procedures or take-back procedures. A follow-up was conducted for 30 days after surgery. We chose 2019 to be the final cohort year to ensure that patient selection was not affected by the COVID-19 pandemic. We prepared the report according to Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines[7] (Supplementary Materials). This study was approved by the Stanford University Institutional Review Board (IRB-43022). The Veterans Affairs Surgical Quality Improvement Program is a quality-improvement registry; individual informed consent is not obtained for inclusion.

Patient factors

For each case, we abstracted the surgical approach (URS, ESWL, PCNL) and relevant comorbidities. We collected clinicodemographic variables such as age, sex, body mass index (BMI), race, year of surgery, and comorbidities (coronary artery disease, congestive heart failure, chronic kidney disease, chronic pulmonary disease, diabetes, hypertension, peripheral vascular disease) at the time of surgery, as well as serum albumin concentration. We analyzed age as a continuous variable. We used the Charlson Comorbidity Index to assess overall patient comorbidity, with scores ranging from 0 (indicating no comorbidity) to a maximum of 37 points.

Outcomes

Primary outcomes were any diagnosis of sepsis, hospital readmission, and all-cause mortality within 30 days of the index surgery. We assessed post-operative sepsis using ICD-9 and ICD-10 codes that were evaluated by numerous authors (IT, AH, JL, SC) and discussed until agreement was reached (Supplementary Methods). We considered hospital readmission using VA encounter data, and all-cause mortality within 30 days of surgery as reported by the VA Vital Status File.

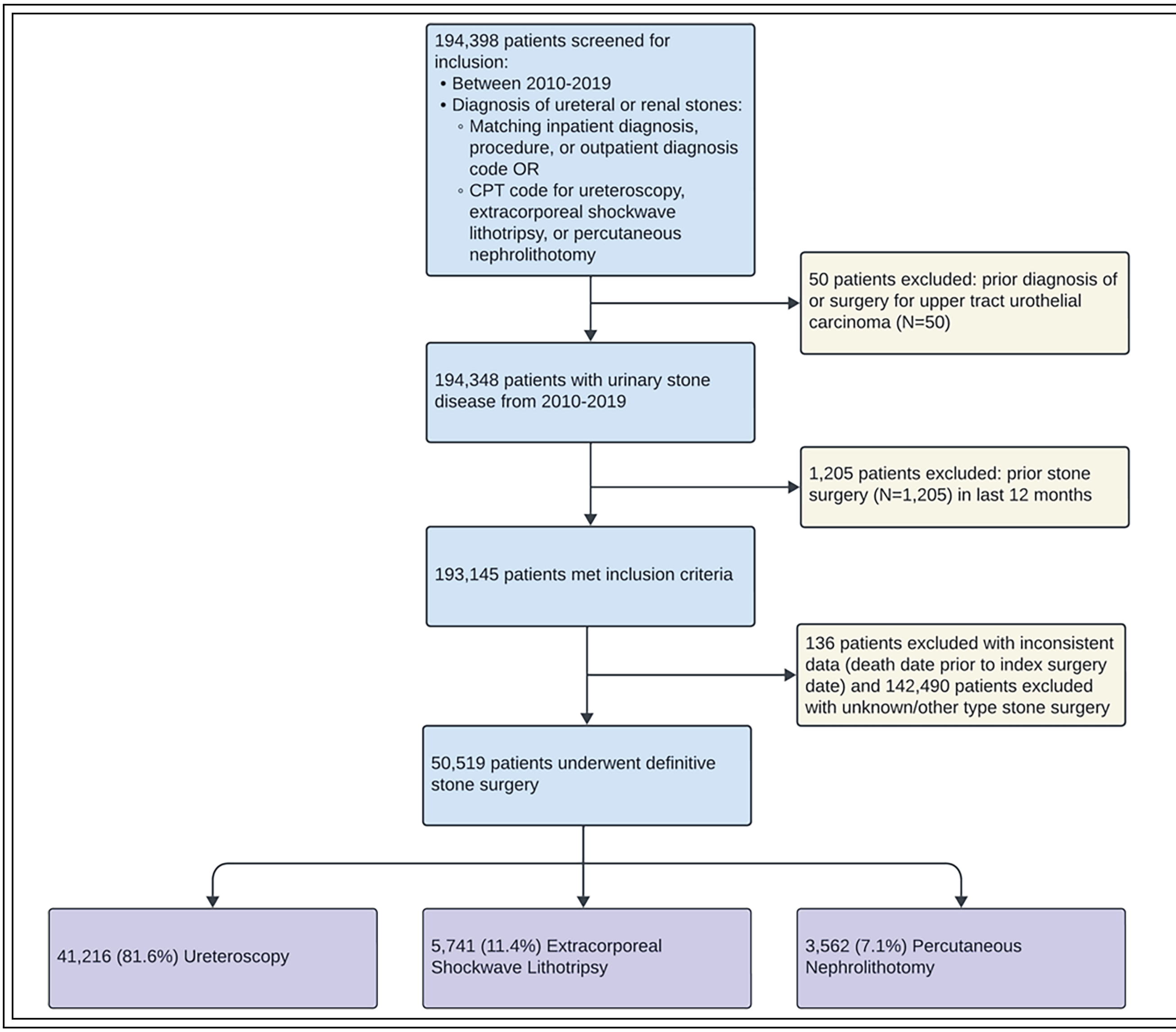

FIGURE 1. Cohort diagram

Statistical analysis

Univariable and multivariable logistic regression models were constructed to analyze the association between patient factors and outcomes, with reporting of adjusted odds ratios (aOR) and 95% confidence intervals (CI). Demographic and clinical data were included as covariates in multivariable modeling, including age, sex, BMI, race, year of surgery, coronary artery disease, congestive heart failure, chronic kidney disease, chronic pulmonary disease, diabetes, hypertension, peripheral vascular disease, serum creatinine, and serum albumin. We examined age as a continuous variable, reporting aORs per 5-year increase. We analyzed all combined USD procedures to describe differences in outcomes. However, since the surgical approach is subject to significant selection bias and is influenced by various patient, anatomic, and stone characteristics, we also examined clinical outcomes for each procedure separately. Missing data were not imputed and are described in Table 1. We set a two-sided statistical significance threshold of $\alpha = 0.05$. Analysis was performed using SAS Enterprise Guide 8.3 (SAS Institute Inc., Cary, NC, USA)

TABLE 1. **Patient characteristics**

Characteristic	Overall, N = 50,519	Sepsis, N = 1834 (3.6%)	Hospital Readmission, N = 4288 (8.5%)	All-Cause Mortality, N = 137 (0.3%)
Type of surgery				
PCNL	3562 (7.1%)	209 (11.4%)	724 (16.9%)	16 (11.7%)
URS	41,216 (81.6%)	1553 (84.7%)	3219 (75.1%)	115 (83.9%)
ESWL	5741 (11.4%)	72 (3.9%)	345 (8.0%)	6 (4.4%)
Age at diagnosis	61.7 ± 13.2	66.1 ± 12.9	64.3 ± 12.8	72.0 ± 12.7
Age at surgery	62.4 ± 13.2	67.0 ± 12.8	65.1 ± 12.7	72.7 ± 12.7
<45	5544 (11.0%)	102 (5.6%)	308 (7.2%)	4 (2.9%)
45–59	12,059 (23.9%)	340 (18.5%)	923 (21.5%)	15 (10.9%)
60–74	26,484 (52.4%)	981 (53.5%)	2284 (53.3%)	58 (42.3%)
≥75	6432 (12.7%)	411 (22.4%)	773 (18.0%)	60 (43.8%)
Sex (Male)	47,473 (94.0%)	1708 (93.1%)	4014 (93.6%)	133 (97.1%)
Race				
White	40,824 (80.8%)	1462 (79.7%)	3479 (81.1%)	117 (85.4%)
Black	5439 (10.8%)	203 (11.1%)	465 (10.8%)	12 (8.8%)
Other	4152 (8.2%)	168 (9.2%)	340 (7.9%)	8 (5.8%)
Missing	104 (0.2%)	1 (0.1%)	4 (0.1%)	0 (0.0%)
Year of surgery				
2010	4338 (7.8%)	101 (5.5%)	402 (9.4%)	13 (9.5%)
2011	4463 (8.0%)	94 (5.1%)	384 (9.0%)	10 (7.3%)
2012	4710 (8.5%)	114 (6.2%)	398 (9.3%)	14 (10.2%)
2013	4948 (8.9%)	154 (8.4%)	388 (9.0%)	18 (13.1%)
2014	5071 (9.1%)	158 (8.6%)	434 (10.1%)	12 (8.8%)
2015	5079 (9.1%)	198 (10.8%)	439 (10.2%)	10 (7.3%)
2016	5274 (9.5%)	204 (11.1%)	426 (9.9%)	12 (8.8%)
2017	5449 (9.8%)	224 (12.2%)	420 (9.8%)	14 (10.2%)
2018	5477 (9.9%)	270 (14.7%)	490 (11.4%)	17 (12.4%)
2019	5710 (10.3%)	317 (17.3%)	507 (11.8%)	17 (12.4%)
Serum albumin (g/dL)	3.9 ± 0.5	3.5 ± 0.7	3.7 ± 0.6	3.2 ± 0.8
BMI	30.3 ± 6.2	29.5 ± 7.2	29.9 ± 6.7	27.5 ± 7.7
<29	9431 (18.7%)	497 (27.1%)	988 (23.0%)	55 (40.1%)
26–30	17,571 (34.8%)	599 (32.7%)	1419 (33.1%)	40 (29.2%)
≥30	23,452 (46.4%)	735 (40.1%)	1874 (43.7%)	39 (28.5%)
Missing	65 (0.1%)	3 (0.2%)	7 (0.2%)	3 (2.2%)
CCI	1.9 ± 2.1	3.3 ± 2.7	2.7 ± 2.4	4.3 ± 2.9
0	15,814 (31.3%)	267 (14.6%)	891 (20.8%)	10 (7.3%)
1	10,369 (20.5%)	250 (13.6%)	702 (16.4%)	11 (8.0%)
2	9275 (18.4%)	325 (17.7%)	824 (19.2%)	20 (14.6%)
3	6114 (12.1%)	278 (15.2%)	613 (14.3%)	19 (13.9%)
4	3604 (7.1%)	238 (13.0%)	431 (10.1%)	22 (16.1%)
5	2053 (4.1%)	137 (7.5%)	284 (6.6%)	14 (10.2%)
6+	3290 (6.5%)	339 (18.5%)	543 (12.7%)	41 (29.9%)
Comorbidities				
CAD	10,747 (21.3%)	603 (32.9%)	1260 (29.4%)	58 (42.3%)
CHF	4941 (9.8%)	349 (19.0%)	657 (15.3%)	48 (35.0%)
CKD	6263 (12.4%)	427 (23.3%)	814 (19.0%)	51 (37.2%)
CPD	11,337 (22.4%)	597 (32.6%)	1247 (29.1%)	46 (33.6%)
DM	17,926 (35.5%)	866 (47.2%)	1772 (41.3%)	71 (51.8%)
HTN	34,056 (67.4%)	1440 (78.5%)	3203 (74.7%)	107 (78.1%)
PVD	5880 (11.6%)	373 (20.3%)	725 (16.9%)	50 (36.5%)

Note. Data are presented in the format of n (%) or mean ± SD. Abbreviations: URS, ureteroscopy; ESWL, extracorporeal shockwave lithotripsy; PCNL, percutaneous nephrolithotomy; BMI, body mass index; CCI, Charlson Comorbidity Index; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; CPD, chronic pulmonary disease; DM, diabetes mellitus; HTN, hypertension; PVD, peripheral vascular disease.

in the VA Informatics and Computing Infrastructure Platform.

Results

We examined 50,519 unique patients who underwent procedures for USD (Figure 1). The number of patients (percentages) for each procedure was the following: 41,216 (81.6%) for URS, 5741 (11.4%) for ESWL, and 3562 (7.1%) for PCNL. A total of 47,473 (94.0%) patients were male, and the mean age at surgery was 62.4 ± 13.2 years. (Table 1). By age, 5544 (11.0%) patients were <45 years old, 12,059 (23.9%) patients were 45–59 years old, 26,484 (52.4%) patients were 60–74 years old, and 6432 (12.7%) patients were ≥75 years old. The average Charlson Comorbidity Index was 1.9 ± 2.1, and the most commonly listed comorbidity was hypertension (67.4%), followed by diabetes (35.5%) (Table 1).

URS was the most common surgical approach for USD among all age groups (Figure 2). From 2010 to 2019, there was an increase in the number of URS performed as a patient's first stone procedure from 3097 (71.4%) to 5085 (89.1%) per year while there was a decrease in the number of ESWL procedures from 860 (19.8%) to 290 (5.1%) and in the number of PCNL procedures from 381 (8.8%) to 335 (5.9%) per year. Age of patients undergoing surgical management of USD are is illustrated in Supplementary Figure S1.

Within 30 days of surgery, 1834 (3.6%) patients were diagnosed with post-operative sepsis, and 4288 (8.5%) patients had a hospital readmission. Additionally, there were 137 (0.3%) all-cause mortality events within 30 days (Table 1). In multivariable analysis, URS and PCNL were associated with higher odds of nearly all adverse clinical outcomes when compared with ESWL (Table 2). All other covariates are reported in Table 2.

Among URS cases, increasing age was associated with sepsis (aOR per 5-year increase 1.03, 95% CI: 1.00–1.05), hospital readmission (aOR = 1.03, 95% CI: 1.01–1.05), and all-cause mortality within 30 days (aOR = 1.19; 95% CI: 1.09–1.30) (Table 3). For ESWL cases, no significant associations were found between age and hospital readmission, but lower odds of sepsis with age were observed (aOR = 0.87 per 5-year increase; 95% CI: 0.78–0.98) (Supplementary Table S1). All-cause mortality after ESWL was unable to be assessed in multivariable analysis due to a low number of events (N = 6), however, no association between age and all-cause mortality after ESWL was found in univariable analysis (Supplementary Table S2). For PCNL cases, no significant associations were found between age and sepsis or hospital readmission (Supplementary Table S3). All-cause mortality after PCNL was also not assessed in multivariable analysis due to the low number of events (N = 16), however, no association between age and all-cause mortality after PCNL was found in univariable analysis (Supplementary Table S4). No significant interaction was observed between age and year of surgery as a predictor for poor outcomes (Supplemental Table S5).

Discussion

In a large national cohort of Veterans undergoing USD surgery, we found that after adjusting for confounding variables, older age was significantly associated with sepsis, hospital readmission, and all-cause mortality within 30 days of surgery. Age was associated with poor outcomes only in the URS subgroup, and no age-related risk was observed with ESWL and PCNL. In our cohort, we reported the safety profile of URS, EWSL, and PCNL among an older patient population. While relatively few patients died within 30 days (0.3%), 3.6% of patients developed sepsis, and 8.5% were readmitted to the hospital within 30 days.

Patients 60 years and older with USD comprise nearly 12% of all stone formers, and the number of patients in this group is expected to rise as life expectancy increases.[3] Older patients with USD are likely to have comorbidities that may complicate surgical intervention for stone removal. In this cohort of Veterans, we found that URS was the most common surgical approach, with utilization increasing over time. Our findings that older age was associated with adverse post-operative outcomes following URS are consistent with reports in the literature. Studies have identified that older patients undergoing URS experience longer operative times, more severe and more common intraoperative complications, longer convalescence, and more secondary interventions.[3,8–11] Our study revealed 3.8% of patients undergoing URS were diagnosed with sepsis within 30 days, similar to other studies reporting that 0.1–4.3% of patients developed sepsis following URS.[12–14] In patients who underwent URS, 1.6% of patients younger than 45 years old developed sepsis, 2.3% of patients aged 45–59 developed sepsis, 3.1% of patients aged 60–74 developed sepsis, and 5.7% of patients aged ≥75 developed sepsis. While two single and multi-center studies have found few or no cases of complications following URS in their smaller cohorts[12,13], we believe that our study of a large nationally distributed cohort

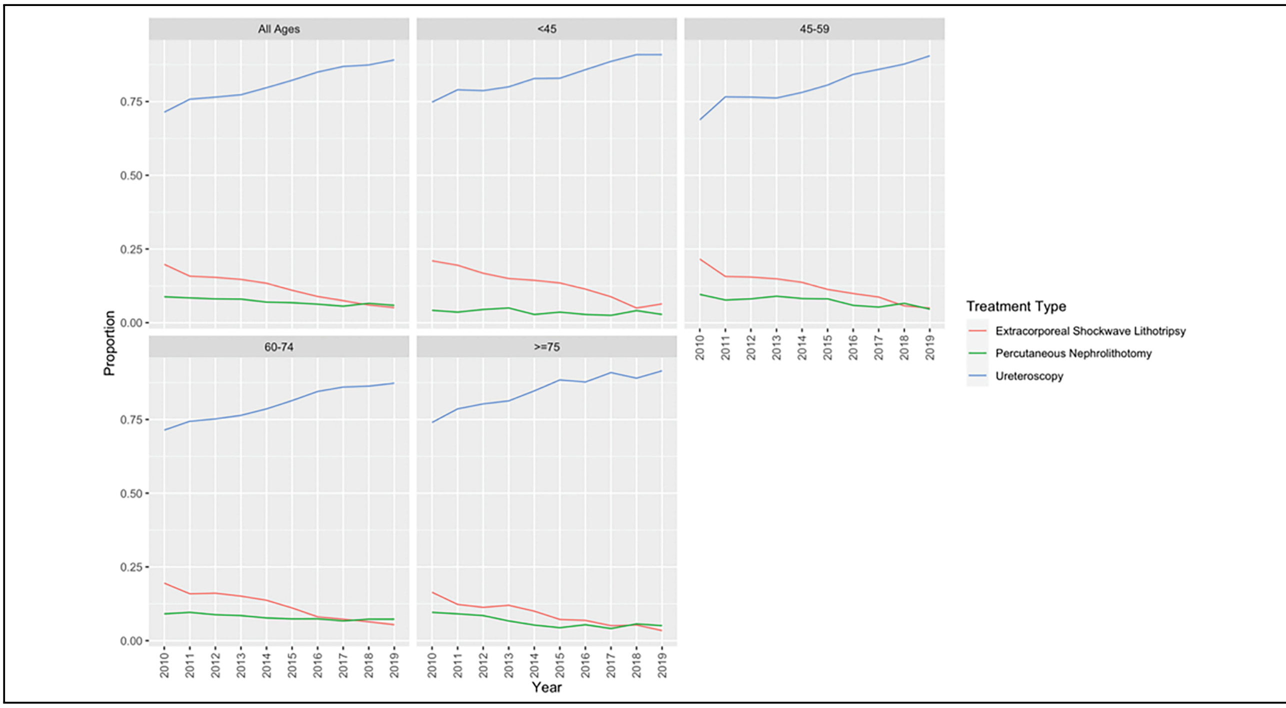

FIGURE 2. Yearly trends in surgical modality for treatment of urinary stone disease stratified by age

of Veterans enabled us to detect significant associations between age and the risk of sepsis and other poor post-operative outcomes following URS. The reason why age leads to worse outcomes after URS is unclear and warrants further investigation, but overall frailty and difficult-to-measure differences in immune function and cardiovascular health may contribute, as well as other unmeasured confounders in medical and surgical management, such as use of pre-stenting, intra-operative decision making, and post-operative care may contribute. Ultimately, our findings add new details to pre-operative risk counseling, treatment selection, and pre-operative medical optimization when deciding whether to pursue surgical management of USD.

In our study, patients who received ESWL had fewer adverse events when compared with those who underwent URS and PCNL. While ESWL has been reported to have less morbidity, it is likely that patients selected for ESWL differ from those requiring URS or PCNL.[4] Overall, increasing age was not an independent predictor of poor outcomes in patients undergoing ESWL. This finding is supported by a number of cohort studies, which found ESWL to be associated with lower rates of severe complications in older populations.[15–18] Although we found that PCNL had higher rates of ICU admission and hospital readmission compared to URS, increasing age was not associated with higher odds of poor outcomes. In particular, prior studies have found that PCNL is associated with higher rates of more severe intraoperative and postoperative complications, postoperative blood transfusions, and readmission, especially in older patients.[19–21] However, a number of other studies have found no difference in major complication rates among older patients undergoing urologic procedures.[22–26] Our negative findings may have been subject to selection bias, as PCNL, despite being more appropriate for surgically complex cases, may be more likely to be chosen for older patients with stone disease who are healthy, less frail, and better able to tolerate the physiologic demands of the procedure due to the higher risk of morbidity and mortality. In this study, URS was increasingly utilized over the 10-year period, while the number of PCNL and ESWL procedures declined, suggesting ESWL and PCNL are increasingly being reserved for more select cases.

The use of surgical approaches for stone disease did not vary significantly by age, suggesting that in the VHA, urologists do not seem to be selecting an operative approach based on age alone. We also found that more recent surgeries were significantly associated with higher odds of sepsis despite no change in hospital readmission or all-cause mortality

TABLE 2. **Multivariable modeling of all cases**

Characteristic	aOR (95% CI)		
	Sepsis	Hospital readmission	All-cause mortality
Type of surgery			
ESWL	Ref	Ref	Ref
PCNL	3.27 (2.48, 4.31)	3.43 (2.99, 3.94)	2.53 (0.98, 6.54)
URS	2.19 (1.72, 2.79)	1.20 (1.06, 1.35)	1.77 (0.77, 4.07)
Age at surgery (+5yr)	1.02 (1.00, 1.05)	1.02 (1.01, 1.04)	1.19 (1.10, 1.29)
Year of surgery (+1yr)	1.10 (1.08, 1.12)	0.99 (0.98, 1.00)	0.96 (0.90, 1.02)
Serum albumin (+0.1 g/dL)	0.88 (0.87, 0.89)	0.95 (0.94, 0.96)	0.87 (0.84, 0.89)
Race			
White	Ref	Ref	Ref
Black	0.83 (0.71, 0.97)	0.91 (0.82, 1.01)	0.64 (0.35, 1.17)
Other	1.18 (1.00, 1.40)	0.99 (0.88, 1.11)	0.71 (0.34, 1.46)
Male sex (Ref: Female)	0.69 (0.57, 0.85)	0.77 (0.68, 0.89)	1.10 (0.40, 3.04)
BMI			
<25	Ref	Ref	Ref
26–29	0.77 (0.68, 0.88)	0.83 (0.76, 0.91)	0.60 (0.39, 0.91)
≥30	0.66 (0.58, 0.76)	0.79 (0.73, 0.87)	0.47 (0.30, 0.73)
Comorbidities			
CAD	1.23 (1.09, 1.38)	1.25 (1.15, 1.35)	1.16 (0.78, 1.71)
CHF	1.11 (0.97, 1.28)	1.17 (1.06, 1.29)	2.00 (1.33, 2.99)
CKD	1.16 (1.03, 1.32)	1.25 (1.15, 1.37)	1.62 (1.10, 2.38)
CPD	1.19 (1.07, 1.33)	1.19 (1.10, 1.28)	0.89 (0.61, 1.30)
DM	1.28 (1.15, 1.42)	1.10 (1.02, 1.18)	1.41 (0.97, 2.03)
HTN	1.26 (1.11, 1.43)	1.15 (1.06, 1.25)	0.75 (0.48, 1.18)
PVD	1.11 (0.98, 1.26)	1.13 (1.04, 1.24)	1.88 (1.28, 2.75)

Note. Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; Ref, reference; URS, ureteroscopy; ESWL, extracorporeal shockwave lithotripsy; PCNL, percutaneous nephrolithotomy; BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; CPD, chronic pulmonary disease; DM, diabetes mellitus; HTN, hypertension; PVD, peripheral vascular disease.

by year. Studies have found that sepsis diagnoses are rising despite stable or declining measures of corresponding clinical markers and sepsis-related mortality, suggesting that the higher incidence of sepsis may be more related to more inclusive diagnostic coding practices.[27,28] The strength of age as a risk factor for poor outcomes did not change over time despite a slight increase in the number of operations performed on older patients in our cohort, suggesting that quality of care for older patients has also remained stable in recent years.

This study was limited by its retrospective nature and by only examining outcomes within 30 days of surgery. This study could not capture stone characteristics (size and location), symptomatic presentations of the patients, or how long patients remained stone-free. The study also could not discern relevant intraoperative details that may have influenced outcomes in patients of our cohort. As the study population was largely white male patients in the VHA, these results may not necessarily generalize to other groups of people. We were also not able to capture a comparator group of USD patients who were not surgically managed, which subjects our results to selection bias. While this analysis includes analysis of USD cases from chronic stone formers, this study excluded patients with recurrent episodes. Patients undergoing recurrent procedures may be at a higher risk of post-operative adverse events. Lastly, recent technological advances in ureteroscopy that may lower the risk of sepsis, such as high-powered laser systems and suction access sheaths, may not have been captured within this cohort.[29,30]

This study has several strengths. We included a large cohort of older patients with USD from the largest integrated national healthcare system in the

TABLE 3. **Multivariable modeling of ureteroscopy cases**

Characteristic	aOR (95% CI)		
	Sepsis	Hospital readmission	All-cause mortality
Age at surgery (+5yr)	1.03 (1.00, 1.05)	1.03 (1.01, 1.05)	1.19 (1.09, 1.30)
Year of surgery			
2010	Ref	Ref	Ref
2011	0.82 (0.59, 1.14)	0.93 (0.78, 1.11)	0.84 (0.30, 2.35)
2012	0.96 (0.71, 1.31)	0.88 (0.74, 1.04)	1.15 (0.46, 2.87)
2013	1.20 (0.90, 1.60)	0.76 (0.64, 0.91)	1.41 (0.59, 3.37)
2014	1.19 (0.90, 1.59)	0.81 (0.69, 0.97)	0.98 (0.40, 2.45)
2015	1.49 (1.14, 1.97)	0.81 (0.68, 0.96)	0.73 (0.28, 1.92)
2016	1.29 (0.98, 1.70)	0.72 (0.60, 0.85)	0.63 (0.24, 1.62)
2017	1.45 (1.11, 1.90)	0.72 (0.61, 0.86)	0.87 (0.35, 2.13)
2018	1.76 (1.36, 2.30)	0.83 (0.70, 0.97)	0.83 (0.34, 2.02)
2019	2.03 (1.56, 2.62)	0.82 (0.70, 0.97)	0.81 (0.34, 1.94)
Serum albumin (+0.1 g/dL)	0.88 (0.87, 0.89)	0.95 (0.94, 0.95)	0.87 (0.84, 0.89)
Race			
White	Ref	Ref	Ref
Black	0.84 (0.71, 1.00)	0.93 (0.83, 1.05)	0.49 (0.24, 1.03)
Other	1.11 (0.92, 1.33)	0.96 (0.84, 1.10)	0.61 (0.26, 1.40)
Male sex (Ref: Female)	0.63 (0.51, 0.77)	0.77 (0.66, 0.90)	1.74 (0.42, 7.22)
BMI			
<25	Ref	Ref	Ref
26–29	0.76 (0.66, 0.87)	0.84 (0.76, 0.93)	0.58 (0.37, 0.93)
≥30	0.64 (0.56, 0.74)	0.78 (0.71, 0.86)	0.44 (0.27, 0.72)
Comorbidities			
CAD	1.26 (1.11, 1.43)	1.27 (1.17, 1.39)	1.17 (0.77, 1.80)
CHF	1.09 (0.94, 1.27)	1.18 (1.05, 1.32)	2.23 (1.44, 3.46)
CKD	1.13 (0.99, 1.30)	1.26 (1.14, 1.39)	1.63 (1.07, 2.48)
CPD	1.22 (1.09, 1.37)	1.19 (1.09, 1.29)	0.89 (0.59, 1.34)
DM	1.30 (1.16, 1.45)	1.12 (1.04, 1.22)	1.60 (1.06, 2.41)
HTN	1.26 (1.10, 1.45)	1.20 (1.09, 1.31)	0.71 (0.43, 1.18)
PVD	1.12 (0.97, 1.28)	1.16 (1.04, 1.28)	2.01 (1.34, 3.03)

Note. Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; Ref, reference; BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; CPD, chronic pulmonary disease; DM, diabetes mellitus; HTN, hypertension; PVD, peripheral vascular disease.

United States. We had access to inpatient and outpatient diagnostic claims along with laboratory results. This study also investigated a wide range of outcomes, which enabled an evaluation of how age modifies clinically relevant and patient-centered outcomes.

Conclusions

For patients who undergo a surgical procedure for USD, older age was associated with increased odds for sepsis, hospital readmission, ICU admission, and all-cause mortality within 30 days of surgery. When each surgical approach was evaluated separately, older age continued to be associated with poor outcomes after URS, but this association was not seen following ESWL or PCNL. This may reflect increasing utilization of URS to treat USD in older patients. These results inform patient counselling, treatment selection, and pre-operative medical optimization for older patients with USD.

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Author Contributions

Jonathan J. Song: Methodology, Software, Validation, Formal Analysis, Investigation, Writing—Original Draft, Writing—Review & Editing, Visualization; I-Chun (Jinn) Thomas: Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Visualization; Amber Herbert: Investigation, Data Curation, Writing—Original Draft, Writing—Review & Editing; Calyani Ganesan: Investigation, Writing—Review & Editing; Alan C. Pao: Investigation, Writing—Review & Editing, Funding Acquisition; Timothy Chang: Writing—Original Draft, Writing—Review & Editing; Ryan R. Sun: Writing—Original Draft, Writing—Review & Editing; John Leppert: Methodology, Investigation, Resources, Writing—Original Draft, Supervision, Project Administration, Funding Acquisition; Simon L Conti: Conceptualization, Methodology, Investigation, Writing—Original Draft, Supervision, Project Administration. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

The data sets generated and/or analyzed during the current study are available from the corresponding author, SC, on reasonable request.

Ethical Approval

This study was approved by the Stanford University Institutional Review Board (IRB-43022). The Veterans Affairs Surgical Quality Improvement Program is a quality-improvement registry; individual informed consent is not obtained for inclusion.

Conflicts of Interest

The authors declare no conflicts of interest.

Supplementary Materials

The supplementary material is available online at https://www.techscience.com/doi/10.32604/cju.2026.074683/s1. Supplementary Figure S1. Age of Patients Undergoing Surgical Management of USD over Time. Supplementary Table S1. Multivariable Modeling of ESWL Cases with Sepsis and Hospital Readmission. Supplementary Table S2. Univariable Modeling of ESWL Cases with All-Cause Mortality. Supplementary Table S3. Multivariable Modeling of PCNL Cases with Sepsis and Hospital Readmission. Supplementary Table S4. Univariate Modeling of PCNL Cases with All-Cause Mortality. Supplementary Table S5. Multivariable Interaction Testing Between Age and Year with Poor Outcome after URS, ESWL, or PCNL.

Abbreviations

USD	Urinary Stone Disease
URS	Ureteroscopy
ESWL	Extracorporeal Shockwave Lithotripsy
PCNL	Percutaneous Nephrolithotomy
VHA	Veterans Health Administration
BMI	Body-mass-index
CCI	Charlson Comorbidity Index
CAD	Coronary artery disease
CHF	Congestive heart failure
CKD	Chronic kidney disease
CPD	Chronic pulmonary disease
DM	Diabetes mellitus
HTN	Hypertension
PVD	Peripheral vascular disease

References

1. Hill AJ, Basourakos SP, Lewicki P et al. Incidence of kidney stones in the united states: the continuous national health and nutrition examination survey. *J Urol* 2022;207(4):851–856. doi:10.1097/ju.0000000000002331.
2. Tundo G, Vollstedt A, Meeks W, Pais V. Beyond prevalence: annual cumulative incidence of kidney stones in the United States. *J Urol* 2021;205(6):1704–1709. doi:10.1097/JU.0000000000001629.
3. Emiliani E, Piccirilli A, Cepeda-Delgado M et al. Flexible ureteroscopy in extreme elderly patients (80 years of age and older) is feasible and safe. *World J Urol* 2021;39(7):2703–2708. doi:10.1007/s00345-020-03448-w.
4. Assimos D, Krambeck A, Miller NL et al. Surgical management of stones: American Urological Association/Endourological Society Guideline, PART II. *J Urol* 2016;196(4):1161–1169. doi:10.1016/j.juro.2016.05.091.
5. Sanci A, Durak HM, Ekenci BY et al. Older age is not a contraindication for retrograde intrarenal surgery. *Arch Esp Urol* 2024;77(9):965–970. doi:10.56434/j.arch.esp.urol.20247709.137.
6. Strøm C, Rasmussen LS, Sieber FE. Should general anaesthesia be avoided in the elderly?. *Anaesthesia* 2014;69(Suppl 1):35–44. doi:10.1111/anae.12493.
7. von Elm E, Altman DG, Egger M et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg* 2014;12(12):1495–1499. doi:10.1097/ede.0b013e3181577654.
8. Cakici MC, Sari S, Selmi V, Sandikci F, Karakoyunlu N, Ozok U. Is the efficacy and safety of retrograde flexible ureteroscopy in the elderly population different from non-elderly adults? *Cureus* 2019;11(6):e4852. doi:10.7759/cureus.4852.
9. Giulioni C, Brocca C, Gauhar V et al. Does age impact outcomes of retrograde intrarenal surgery in the elderly? Results from 366 patients from the FLEXible ureteroscopy outcomes registry (FLEXOR). *Aging Clin Exp Res* 2023;35(11):2711–2719. doi:10.1007/s40520-023-02545-1.
10. Gokcen K, Dundar G, Bagcioglu M, Karagoz MA, Gokce G, Sarica K. Safety and efficacy of RIRS in geriatric patients: a comparative evaluation on an age based manner. *Urol J* 2020;17(2):129–133.
11. Solomon IP, Klein I, Friefeld Y, Zreik R, Fares G, Dekel Y. Ureteroscopy in the elderly: safety and functional results. *World J Urol* 2023;41(8):2179–2183. doi:10.1007/s00345-023-04463-3.
12. Prattley S, Voss J, Cheung S, Geraghty R, Jones P, Somani BK. Ureteroscopy and stone treatment in the elderly (≥70 years): prospective outcomes over 5- years with a review of literature. *Int Braz J Urol* 2018;44(4):750–757. doi:10.1590/S1677-5538.IBJU.2017.0516.
13. Berardinelli F, De Francesco P, Marchioni M et al. RIRS in the elderly: is it feasible and safe? *Int J Surg* 2017;42:147–151. doi:10.1016/j.ijsu.2017.04.062.
14. De Coninck V, Keller EX, Somani B et al. Complications of ureteroscopy: a complete overview. *World J Urol* 2020;38(9):2147–2166. doi:10.1007/s00345-019-03012-1.
15. Chen YZ, Lin WR, Lee CC et al. Comparison of safety and outcomes of shock wave lithotripsy between elderly and non-elderly patients. *Clin Interv Aging* 2017;12:667–672. doi:10.2147/CIA.S134750.
16. Sighinolfi MC, Micali S, Grande M, Mofferdin A, De Stefani S, Bianchi G. Extracorporeal shock wave lithotripsy in an elderly population: how to prevent complications and make the treatment safe and effective. *J Endourol* 2008;22(10):2223–2226. doi:10.1089/end.2008.9704.
17. Lamacchia GB, Korkes F, Baccaglini W, de Mello LGM, Szwarc M, Tobias-Machado M. A large series of extracorporeal shockwave lithotripsy in the very elderly. *Ther Adv Urol* 2019;11:1756287219870412. doi:10.1177/1756287219870412.
18. Philippou P, Lamrani D, Moraitis K, Wazait H, Masood J, Buchholz N. Shock-wave lithotripsy in the elderly: safety, efficacy and special considerations. *Arab J Urol* 2011;9(1):29–33. doi:10.1016/j.aju.2011.03.009.
19. Abedali ZA, Large T, Heiman JM et al. Percutaneous nephrolithotomy in the 80 years of age and older population. *Urology* 2019;134:62–65. doi:10.1016/j.urology.2019.08.044.
20. Haider R, Regnier P, Roustan FR et al. Percutaneous nephrolithotomy for kidney stones in elderly patients: meta-analysis of results and complications. *Prog Urol* 2017;27(2):58–67. doi:10.1016/j.juro.2011.07.065.
21. Johnston AW, Jiang R, Alkazemi MH et al. Nationwide readmission rates following percutaneous nephrolithotomy: does age matter? *J Endourol* 2019;33(9):704–711. doi:10.1089/end.2019.0239.
22. Besiroglu H, Merder E, Dedekarginoglu G. Percutaneous nephrolithotomy is safe and effective in aging male patients: a single center experience. *Aging Male* 2020;23(5):705–710. doi:10.1080/13685538.2019.1581756.
23. Iqbal N, Iqbal S, Hasan A et al. Outcome of tubeless percutaneous nephrolithotomy in elder patients: a single-center experience from a developing country. *J Clin Transl Res* 2022;8(2):160–165. doi:10.18053/jctres.08.202202.008.
24. Gupta R, Mahajan A. Outcomes of percutaneous nephrolithotomy in elderly versus young patients under regional anesthesia: a comparative study. *Urol Ann* 2020;12(3):254–258. doi:10.4103/UA.UA_69_19.
25. Morganstern B, Galli R, Motamedinia P et al. Percutaneous nephrolithotomy in octogenarians and beyond: how old is too old? *Asian J Urol* 2015;2(4):208–213. doi:10.1016/j.ajur.2015.08.005.
26. Sahan M, Yarimoglu S, Savun M, Erdemoglu O, Degirmenci T. The influence of aging on outcomes in patients undergoing percutaneous nephrolithotomy for complete staghorn stones: a retrospective comparative study. *Cureus* 2021;13(11):e20001. doi:10.7759/cureus.20001.
27. Gohil SK, Cao C, Phelan M et al. Impact of policies on the rise in sepsis incidence, 2000–2010. *Clin Infect Dis* 2016;62(6):695–703. doi:10.1093/cid/civ1019.
28. Rhee C, Murphy MV, Li L et al. Comparison of trends in sepsis incidence and coding using administrative claims versus objective clinical data. *Clin Infect Dis* 2015;60(1):88–95. doi:10.1093/cid/ciu750.
29. Kayano S, Matsukawa A, Laukhtina E et al. Impact of suction ureteral access sheath in ureteroscopy/retrograde intrarenal surgery: a systematic review and meta-analysis. *Transl Androl Urol* 2025;14(5):1315–1326. doi:10.21037/tau-2025-138.
30. Ryan JR, Nguyen MH, Linscott JA et al. Ureteroscopy with thulium fiber laser lithotripsy results in shorter operating times and large cost savings. *World J Urol* 2022;40(8):2077–2082. doi:10.1007/s00345-022-04037-9.

