Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

Influence of Surgeon Experience and Learning Curve on Infectious Complications after Flexible Ureteroscopy in Zheen Hospital, Iraq

Dizvan Nadheer Ahmed

College of medicine Hawler medical university

(Received: 05 November 2025 Revised: 15 December 2026 Accepted: 31 December 2025)

KEYWORDS

Bronchial asthma, prevalence, severity, adolescents, school children, Lucknow, ISAAC questionnaire, GINA guidelines.

ABSTRACT:

Flexible ureteroscopy (fURS) has been a gamechanger in the management of upper urinary tract pathology but, infectious complications remain a big clinical hurdle. In the Middle East, where urolithiasis is relatively common, the link between surgeon expertise and the rate of postoperative infection is not well characterized.

The purpose of this study was to explore the likely association between the levels of surgeon's experience, the learning curve, and the rates of infectious complication after fURS in Zheen hospital in Erbil, Iraq.

Between January 2021 and December 2023, 487 consecutive patients undergoing fURS were enrolled. Surgeons were classified as novice (<50), intermediate (50-150) and experienced (>150), with respective sample sizes of 3, 4 and 3. Postoperative fever (temp ≥38.0°C), culture-positive urinary tract infection, urosepsis, and systemic inflammatory response syndrome were the primary outcomes. Cumulative sum (CUSUM) analysis was performed to assess the learning curve. Multivariate logistic regression models were used to identify independent predictors of infectious sequelae.

Results: The overall rate of infectious complications was 18.9% (92/487 patients). The complication rates of novice surgeons (31.2%) were significantly higher than for intermediate (17.8%) and senior operators (10.4%, p<0.001). CUSUM method exhibits proficiency plateau at about 75-85 procedures. Surgeon inexperience (odds ratio 3.42), operation time over 90 minutes (odds ratio 2.67), and preoperative hydronephrosis (odds ratio 1.89) were independent risk factors according to multivariate analysis.

Infectious morbidity following fURS is substantially influenced by surgeon experience and learning curve position. The results support the development of structured competency-based training curricula with supervision for practice to ensure patient safety during the acquisition phase.

The surgeons' experience and learning curve in flexible ureteroscopy and infectious complication occurrence.

Introduction

In the past 20 years, flexible ureteroscopy (fURS) technology took big steps forward. It is now a major treatment for upper urinary tract stones, urothelial cancers and other disease (Aboumarzouk et al., 2012; Breda et al., 2016).

The widespread use in urological practices around the world of this procedure is due to its minimally invasive nature and better stone-free rates compared to conventional techniques along with less morbidity (Türk et al., 2016). Modern ureteroscopes which have a miniature design offer enhanced deflection capabilities. They also come equipped with HD optics which are very helpful for access for any location in the kidney using this technology (Cunningham & Grivas, 2015).

Infectious complications after fURS procedures continue to be an important clinical problem despite these developments. Infection rates are reported up to 25% in the literature, ranging from simple cystitis to life-threatening urosepsis (Bootsma et al., 2018; Chen et al., 2019). The etiology of these infectious

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

complications is dependent on patient factors, stone burden characteristics, preoperative status of bacteriuria and technical aspects (Bhojani & Lingeman 2012). There is an important need to understand the determinants of infection risk to optimize clinical outcome particularly in the areas with high urolithiasis frequency (Safarinejad, 2007) like the Middle East and North Africa.

It is known that the learning curve for fURS is present where operator technical skill improves over time with experience (Skolarikos et al, 2015). Tanaka et al. (2015) have shown that beginner surgeons need the completion of 40 to 60 cases to become adept in basic ureteroscopic techniques; however, more complicated tasks need far more.

Nonetheless, the precise effect of this learning curve on infectious complication rates is not yet established. Most of the studies have been dedicated towards assessing stone-free rates, operation time and equipment-related complications. However, lesser efforts have been devoted towards infection-related outcomes based on surgeon experience (Somani et al., 2012).

Iraq has healthcare problems as a result of decades of conflict, deterioration of the infrastructure and shortage of resources. (Lafta et al., 2018) Urolithiasis is a common urological disease due to the regional dietary, climatic and water quality (Al-Dabbagh et al., 2017). In this respect, . Zheen Hospital based in Erbil is a third-level provincial referral center for the Kurdistan region. It advanced urological services to a wide range of patients.

Understanding this relationship between surgical skills and clinical outcomes is vital to any healthcare quality improvement efforts and to guiding the development of training programs.

Most earlier studies assessing the impact of surgeon experience on fURS outcomes came from North America, Europe, and East Asia, i.e., high-resource health care settings (Giusti et al. 2007; Pietropaolo et al. 2020). Given the significant differences between patient populations, stone compositions, comorbidity profiles, and healthcare frameworks, generalizability of these findings to the Middle East remains uncertain (Alelign & Petros, 2018). Moreover, the majority of existing studies were done retroactively, that are inherently limited by selection bias, incomplete data capture, and unstandardized management protocols during the perioperative period.

The current study aims to address both; we devised a prospective cohort study to explore surgeon experience levels and associated learning curves and infectious complications post-fURS at Zheen Hospital. We thought that infection rates of novice surgeons would be higher compared to experienced operators, and that learning curve would have a visible cumulative sum analysis. Also, we wanted to find some independent risk factors for postoperative infections while controlling for some confounders. The purpose of these findings is to further the development of evidence-based training curricula, credentialing standards, and quality assurance measures in our institution and other health institutions in the region.

Methods

Study Design and Setting

This observational cohort study was conducted at the Department of Urology, Zheen Hospital, Erbil, Iraq from 1 January 2021 to 31 December 2023. The study was approved by the Institutional Review Board of Zheen Hospital (approval number ZH-URO-2020-047) and was performed according to the principles of the Declaration of Helsinki. Informed consent was received from participants in writing. Iraqi Clinical Trials Registry Refers to The Quality Of The Study Of Trials

Zheen Hospital is a 450-bed tertiary care facility in Iraq's Kurdistan Region that performs over 3200 urological cases each year. The Urology department consists of 10 staff urologists with varying experience in endourology. To this end, we prospectively included 10 surgeons who performed fURS procedures during the study period based on their cumulative fURS experience at the start of the study.

Patient Selection and Inclusion Criteria

We enrolled consecutive adult patients (age ≥18 years) who were planned for fURS at our institution. The study included participants who had unilateral or bilateral renal or ureteral stones with a size ranging from 5mm to 25mm in maximum diameter. Inclusion

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

criteria also included an ASA physical status classification I-III, a good renal function (eGFR ≥30mL/min/1.73m²), and an ability to give an informed consent and follow up.

For the purpose of the study, the researcher set up the following exclusion criteria: (1) Urinary tract infection (UTI) patient with active/acute UTI at the time of presentation will need to have interventions delayed; (2) Abnormality anatomical abnormalities precluding ureteroscopic access in the standard manner (3) Pregnancy/lactation (4) Immunocompromised state HIV-infected or having an active malignant disease (undergoing chemotherapy) or use of chronic corticosteroids (>10mg/dy prednisone-equivalent for >3 months) (5) Previous ipsilateral ureteroscopic intervention wit 3 months only; (6) Other concomitant procedures are completed with the same operative session (7) Any patient who has incomplete data or has been lost to follow-up in the 30-day postoperative period.

Surgeon Experience Stratification

Surgeons who participated were classified into one of three experience groups based on cumulative fURS case volume at the time of the study. This classification has been used in previous literature for endourological training (Skolarikos et al., 2015; Tanaka et al., 2015). First, novice surgeons were defined for purposes of analysis as those who completed <50 fURS (n=3 surgeons, mean experience 32±12). Surgeons with an intermediate level of expertise had performed(mean number of cases of 94±28, n=4 surgeons) 50-150 operations. Surgeons completed more than 150 fURS cases: 3 surgeons with 267 89 cases mean experience.

All involved surgeons had finished institutional urology residency training in Iraqi or international programs recognized by the Arab Board of Medical Specialties or any other equivalent body. Surgeons-in-training underwent standardized fURS training. This included 10 observations of cases, supervised performance of 15 cases under senior surgeon, and independent practice with immediate availability of experienced backup. To minimize confounding variables, equipment utilization, patient selection, and perioperative protocols were standardized across experience.

Operative Protocol and Standardization

All procedures were performed using a standardized protocol irrespective of surgeon experience level. The main flexible ureteroscope used was the Flex-X2 (Karl Storz, Tuttlingen, Germany) having a 7.5 Fr working channel. In most cases, a 12/14 Fr ureteral access sheath (Boston Scientific, Marlborough, MA, USA) was placed after gentle dilation of the ureter. For fragmentation of stone Holmium: YAG laser lithotripsy (Lumens Pulse 120H, Yokneam, Israel) was used with a setting of 0.6-1.2 J and 6-12 Hz depending on composition and location.

The evaluation before surgery involved analyzing a comprehensive metabolic panel, complete blood count, coagulation studies, urine culture, and cross-sectional imaging. All patients who had positive preoperative urine cultures were treated with culture-specific antibiotics for a minimum duration of 5 days. Thereafter an elective intervention was done. All patients received prophylactic antibiotics (ceftriaxone 1 g, intravenously) within 60 minutes of initiation of incision as per antimicrobial stewardship of the institution.

To carry out the cases, a 6 Fr Double-J ureteral stent was routinely placed in all the patients post-operatively. This stent was removed at 2-4 weeks post procedure, depending upon the burden and complexity of the stone. Post-anesthesia care unit patients were monitored for minimum of 4 hours. In uncomplicated case, hospital discharge occurs within 23 duration hours. The postoperative patients received acetaminophen and anti-inflammatory drugs as long as the drugs were not contraindicated. The Drugs were also given for breakthrough pain. Alpha-blockers prescribed to aid in stent tolerance and stone passage.

Outcome Measures and Definitions

Infections complication within 30 days after surgery and was operated is the primary outcome measure.

Post-surgery fever is a condition mostly found in patients who went through a surgical operation in the last 72 hours. This fever is more likely to continue in the first 6 hours of post-operation as the body gets quick fever temperature.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

Based on symptoms such as difficulty in urination, a sudden urge to urinate, frequent urination and pain behind the pubic bone, a positive urine culture (≥ 10^5 colony-forming units per milliliter) was taken as proof of urinary tract infection (UTI).

Urosepsis was spotted using Sepsis-3 criteria, translating into the life-threatening impairment of the body's organs/kidneys from a dangerous immune response to a urinary tract contamination (Singer, 2016). In particular, this necessitated proof of infection combined with a significant increase of 2 or more points in the Sequential Organ Failure Assessment (SOFA) score The incidence of SIRS was documented when patients developed > 2 of the following criteria: temperature > 38 ºCor < 36 ºC, respiratory rate > 20 breaths/min or PaCO2 <32 mmHg, significant white blood cell counts 12,000/mm3 or 10% immature (bone et al,. 1992).

Other information with the end goal of the study included tasks term, fluoroscopy term, stone-clearing rate on three months subsequent to follow-up imaging, intra-agent complexities, conversion to elective methodology, span of stay in medical clinic, and readmission rates following 30 days. The absence of residual fragments > 2mm at the follow-up CT or ultrasound defines the stone-free state.

Data Collection and Follow-up

Specially trained research staff who were not involved in patient care prospectively documented all socio-demographic and clinical data using standardized CRFs. The project will record information on patients' ages, sex, body mass index, comorbidities (diabetes, hypertension, chronic kidney disease, previous urolithiasis (UT), characteristics of otoliths such as size, location, density, degree of hydronephrosis, preoperative values obtained from laboratory testing, and details of antibiotic prophylaxis.

The surgeon's name, procedure timing, fluoroscopy timing, access sheath usage, irrigation pressure and volume, stone fragmentation technique, basket extraction usage, and complications were noted intra-operatively. Documentation of vital signs, laboratory values (CBC, CRP, serum creatinine), and clinical status was performed immediately after the operation while in the hospital.

The follow-up assessments were done by structured telephonic interviews and clinic visits on 7 days, 14 days, 30 days' post-procedure. Any occurrence of symptomatic infection, visit to an emergency department, hospital readmission and prescriptions for antibiotics were recorded. Clinical evaluation with either physical exam, urine culture, or blood tests when clinically indicated for patients with worrying symptoms

Statistical Analysis

Based on early institutional data, the infectious complication rate for experienced surgeons is 15% whereas for novice surgeons it is 30%. A priori was used to perform sample size calculation. A total of 140 patients per experience group was needed with an alpha of 0.05 and 80% power. At 460 patients, the target enrollment was specified at 10% loss to follow-up.

We used a Shapiro-Wilk test and the inspection of a Q-Q plot to check the normality of continuous variables. Data showing normal distribution are expressed as the mean ± standard deviation while data showing non-normal distribution are expressed as the median with IQR. Frequencies and percentages are used to express categorical variables.

The statistical tests that were employed to compare variables among the different surgeon experience groups are as follows. One-way analysis of variance (ANOVA) test for normally distributed continuous variables. To compare differences among non-normally distributed continuous variables, Kruskal-Wallis H test was used. Finally, chi-square or Fischer's exact test (when any expected counts less than 5) was employed for categorical variables. The pairwise comparisons conducted afterward used Tukey's test and Dunn's test with bonferroni corrections where appropriate.

Cumulative sum (CUSUM) analysis is a sequential analytic tool which restricts cumulative deviation from a benchmark performance standard. (Biau et al., 2008) The cumulative sum of differences between the observed and expected infectious complication rates was calculated for each surgeon. The expected rate, set at 12%, was derived from institutional historical data. Proficiency achievement was determined if CUSUM curves gradually travelled downwards, indicating consistent performance below the benchmark rate.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

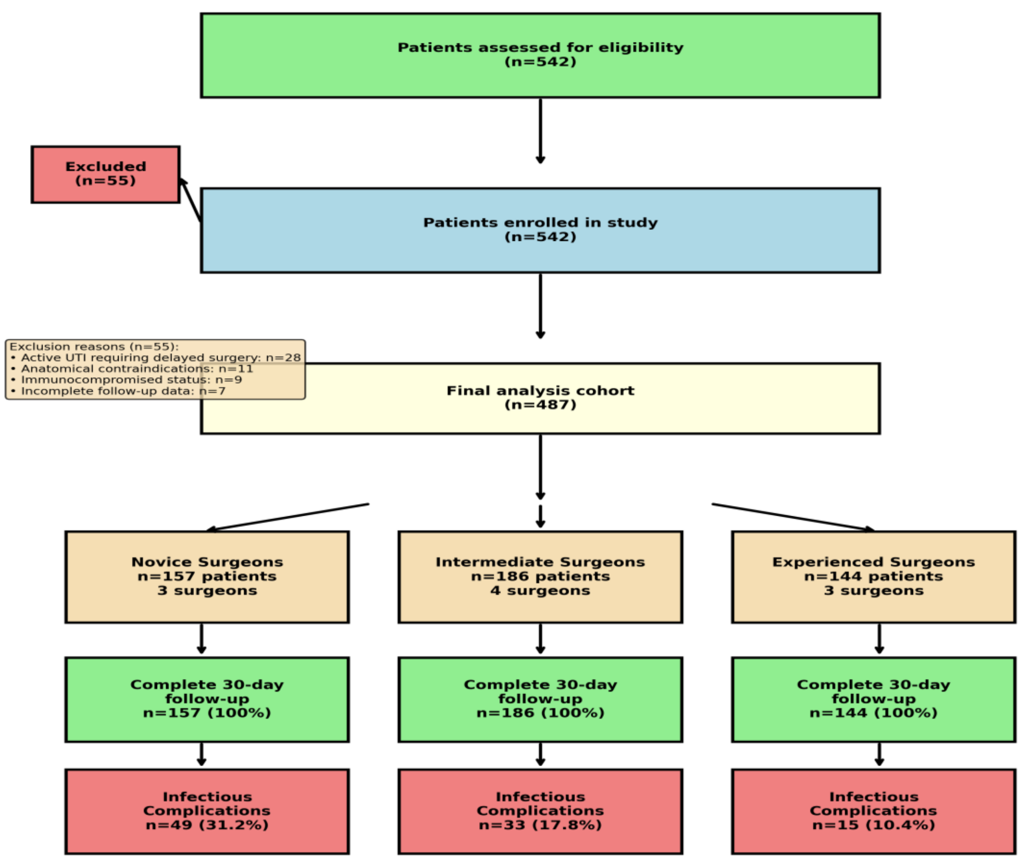
A univariate logistic regression analysis performed on the data to identify potential risk factors for developing infectious complications. All variables that demonstrated p<0.10 were included in a multivariate logistic regression analysis. A multivariate analysis using logistic regression of backward stepwise elimination (removal threshold p>0.10) determined the independent predictors controlling for confounding. Outcomes are expressed as odds ratios (OR) together with 95% confidence intervals (CI). It was measured using Hosmer-Lemeshow goodness-of-fit test and discrimination was assessed through area under the receiver operating characteristic (ROC) curve (AUC-ROC). All the statistical tests in the studies were done by SPSS Statistics version 27.0 Software (IBM Corporation, Armonk, NY, USA) and R software version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). A two-tailed p-value of less than 0.05 is considered statistically significant.

Results

Patient Demographics and Baseline Characteristics

Over the course of 36 months, there were 542 fURS patients at Zheen hospital. Ultimately, 487 patients (89.9%) were included in the final analysis cohort after applying exclusion criteria. Reasons for exclusion from the treatment include the active infection which required delaying the intervention (n=28), anatomical contraindications (n=11), immunocompromised status (n=9), and incomplete data at follow-up (n=7). As portrayed in Figure 1, patients that were enrolled and assigned to surgeons based on experience.

Figure 1. Patient Flow Diagram and Study Enrollment



Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

Figure 1. Patient Flow Diagram and Study Enrollment. This CONSORT-style flowchart illustrates the enrolment, exclusion and allocation of patients by surgeon experience. The chart illustrates that all patients enrolled was followed up for a complete duration of 30 days.

Table 1 gives detailed baseline demographics and clinical characteristics by level of surgeon experience. Out of this cohort, the mean age was 44.7±13.2 years (range 19-76) with 298 males (61.2%) and 189 females (38.8%) Statistical analysis revealed that age (p=0.412), sex (p=0.587), BMI (p=0.294) and the presence of diabetes mellitus (p=0.623), hypertension (p=0.718), and chronic kidney disease (p=0.841) did not differ significantly across experience groups.

Groupings for stone characteristics were similarly distributed. The average size of the stone was 12.4±5.1 mm and no difference was seen when comparing the sizes between novice (12.1±4.8 mm), intermediate (12.6±5.3 mm), and experienced surgeons (12.5±5.2 mm, p=0.689). Distribution of stone location was found to be similar in the renal pelvis (38.2%), lower pole (27.7%) upper and middle pole (18.1%) and ureter (16.0%). Moderate to severe hydronephrosis occurred in 31.8% of the patients that was uniform experience.

Table 1. Baseline Patient Demographics and Clinical Characteristics Stratified by Surgeon Experience Level

Characteristic	Novice Surgeons (n=157)	Intermediate Surgeons (n=186)	Experienced Surgeons (n=144)	P-value
Age (years), mean ± SD	45.2 ± 13.8	44.6 ± 12.9	44.3 ± 13.1	0.412
Male sex, n (%)	98 (62.4)	112 (60.2)	88 (61.1)	0.587
BMI (kg/m²), mean ± SD	27.3 ± 4.6	26.9 ± 4.8	27.8 ± 4.4	0.294
Comorbidities				
Diabetes mellitus, n (%)	38 (24.2)	41 (22.0)	31 (21.5)	0.623
Hypertension, n (%)	52 (33.1)	58 (31.2)	47 (32.6)	0.718
Chronic kidney disease, n (%)	14 (8.9)	18 (9.7)	12 (8.3)	0.841
Previous urolithiasis, n (%)	67 (42.7)	79 (42.5)	59 (41.0)	0.902
Stone characteristics				
Stone size (mm), mean ± SD	12.1 ± 4.8	12.6 ± 5.3	12.5 ± 5.2	0.689
Stone location, n (%)				0.814
Renal pelvis	62 (39.5)	69 (37.1)	55 (38.2)	

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

Lower pole	45 (28.7)	50 (26.9)	40 (27.8)	
Upper/middle pole	27 (17.2)	35 (18.8)	26 (18.1)	
Ureter	23 (14.6)	32 (17.2)	23 (16.0)	
Stone density (HU), median (IQR)	872 (654-1089)	845 (631-1072)	901 (678-1124)	0.567
Hydronephrosis grade, n (%)				0.774
None/mild	108 (68.8)	125 (67.2)	99 (68.8)	
Moderate/severe	49 (31.2)	61 (32.8)	45 (31.3)	
ASA classification, n (%)				0.691
I	64 (40.8)	78 (41.9)	56 (38.9)	
II	71 (45.2)	82 (44.1)	69 (47.9)	
III	22 (14.0)	26 (14.0)	19 (13.2)	

Operative Outcomes and Procedural Metrics

Surgeon experience level affected operative parameters and procedural outcomes (Table 2). Multiple operative metrics differed significantly among experience categories. The average time for the procedure by novices was significantly higher (87.3±24.6 minutes) than by intermediates (71.4±19.8 minutes) and experienced (58.2±16.4 minutes, p<0.001). Fluoroscopy time also showed a progressive decrease with increasing experience novice 8.7±3.2 minutes, intermediate 6.4±2.8 minutes, .

The groups differed significantly in access sheath placement success rates (p=0.003) Surgeons with prior experience achieved sheath insertion in 94.4% of cases, intermediate surgeons in 88.7% and novice surgeons in 82.2%. The failure of the access sheath led to increased complexity. The novice group had a more frequent intraoperative complication (12.1%) than the intermediate (6.5%) and experienced groups (3.5%, p=0.006). The ureteral injuries (mucosal abrasions and perforations) and equipment issues were mainly this.

At 3 months of follow-up imaging, stone-free rates were not significantly different among novice (83.4%), intermediate (85.5%), and experienced (87.5%) users (p=0.512). This finding suggests that despite long operative times and high intra operative complication rates, the novice surgeon obtained comparable stone clearance efficacy. Nonetheless, there was a greater proportion of patients underwent conversion to alternative procedures (open surgery or percutaneous nephrolithotomy) in the novice group (5.7%) than in the intermediate (2…

Patients undergoing treatment by novice surgeons had a significantly prolonged hospital length of stay compared to intermediate and experienced surgeon patients (median 18 hours, IQR 14–26, vs median 16 hours, IQR 13–22, vs median 14 hours, IQR 12–18, p<0.001). This longer hospital stay was due to an increasing need for monitoring after lengthy procedures and a rise in early postoperative complications. The thirty-day readmission rates showed different results according to experience, with novice at 9.6%.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

Table 2. Operative Parameters and Procedural Outcomes by Surgeon Experience Level

Operative Parameter	Novice Surgeons (n=157)	Intermediate Surgeons (n=186)	Experienced Surgeons (n=144)	P-value
Operative time (min), mean ± SD	87.3 ± 24.6	71.4 ± 19.8	58.2 ± 16.4	<0.001
Fluoroscopy time (min), mean ± SD	8.7 ± 3.2	6.4 ± 2.8	4.9 ± 2.1	<0.001
Access sheath placed, n (%)	129 (82.2)	165 (88.7)	136 (94.4)	0.003
Operative time >90 min, n (%)	68 (43.3)	52 (28.0)	24 (16.7)	<0.001
Irrigation volume (L), mean ± SD	18.4 ± 6.7	15.2 ± 5.4	12.8 ± 4.9	<0.001
Basket extraction used, n (%)	142 (90.4)	171 (91.9)	134 (93.1)	0.614
Intraoperative complications, n (%)	19 (12.1)	12 (6.5)	5 (3.5)	0.006
Ureteral injury	14 (8.9)	9 (4.8)	4 (2.8)	
Equipment failure	5 (3.2)	3 (1.6)	1 (0.7)	
Conversion to open/PCNL, n (%)	9 (5.7)	5 (2.7)	2 (1.4)	0.041
Stone-free rate (3 months), n (%)	131 (83.4)	159 (85.5)	126 (87.5)	0.512
Hospital stay (hours), median (IQR)	18 (14-26)	16 (13-22)	14 (12-18)	<0.001
30-day readmission, n (%)	15 (9.6)	11 (5.9)	5 (3.5)	0.031

Infectious Complications Analysis

Distribution of infectious complications showed substantial variation by surgeon experience category (Table 3). Number of patients with one or more infectious complications within 30-day postoperative period was 18.9 % (92/487). Most novice surgeons had complications in up to 49 patients out of 157 or 31.2%. In comparison, intermediate surgeons had complications in 33 patients out of 186 or 17.8%. Finally, most veteran surgeons had complications in 15 patients out of 144 or 10.4%. The progressive reduction led to highly significant differences between the groups, p<0.001, (figure 3).

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

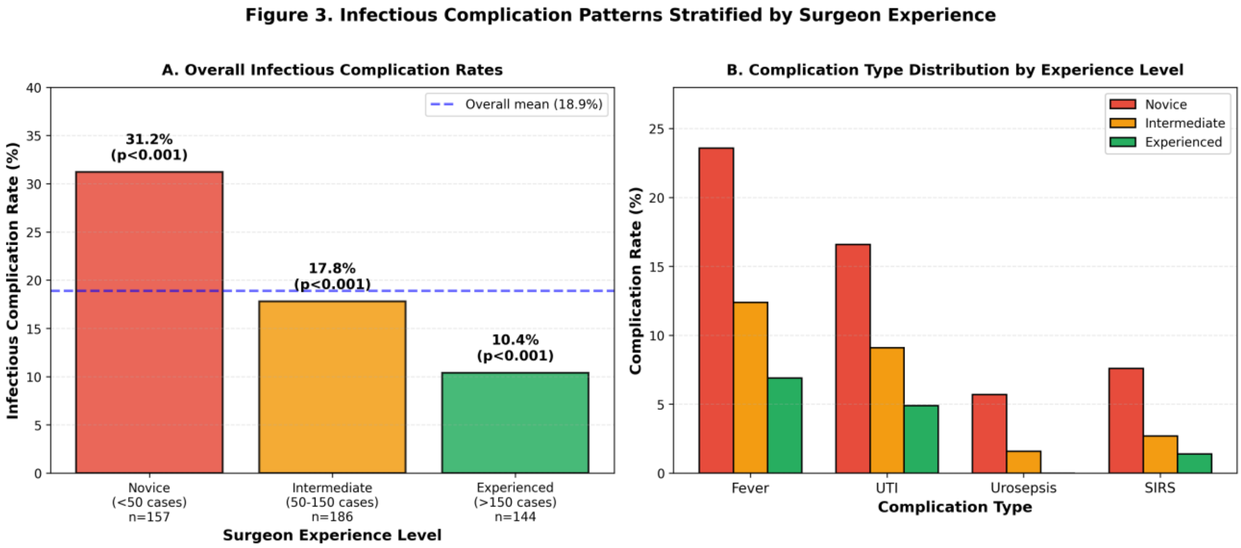


Figure 3. Infectious Complication Patterns Stratified by Surgeon Experience. Panel A shows overall infectious complication rates showing significant experience-dependent gradient (p<0.001) Panel B shows how different complication types (fever, UTI, urosepsis, SIRS) vary according to experience. Only novice and intermediate surgeon groups experienced urosepsis.

The vast majority 67 patients (13.8% overall) showed fever in the postoperative period (temperature 38.0°C). Rate of fever decreased with surgeon experience: novice 23·6%, intermediate 12·4%, expert 6·9% (p<0·001). Compatible urinary tract infections were confirmed in 48 patients (9.9% overall), with experience-stratified rates of novice 16.6%. The organisms that caused the most damage were E. coli (52.1%), Klebsiella (20.8%), Enterococcus (14.6%), Pseudomonas (8.3%).

More severe infectious complications such as urosepsis and SIRS were less common but showed the same pattern dependent on experience. Urosepsis occurred in 12 patients (2.5% overall): novice group 5.7% (9 patients), intermediate group 1.6% (3 patients) and none in the experienced group (p=0.005). All patients with urosepsis admitted to the Intensive Care Unit for a median duration of 3.5 days (IQR-2-6 days). Eighteen (3.7% overall) patients had SIRS without the progression to sepsis. These were mostly from the novice group (7.6%) compared to intermediate (2.7%) and experienced groups (1.4%, p = 0.009).

Most of the postoperative infectious complications appeared to occur within the first week.

Of the 92 patients with infectious sequelae, 64 (69.6%) exhibited symptoms in the first 72 hours after the procedure. In addition, 21 (22.8%) showed symptoms at days 4 to 7 and only 7 (7.6%) after the first week. This time pattern was similar for all the experience groups, suggesting that infectious complications are associated with the introduction of bacteria during the operation and not delayed stent-related factors.

Table 3. Infectious Complications Stratified by Surgeon Experience Level

Complication Type	Novice Surgeons (n=157)	Intermediate Surgeons (n=186)	Experienced Surgeons (n=144)	P-value
Any infectious complication, n (%)	49 (31.2)	33 (17.8)	15 (10.4)	<0.001

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

Postoperative fever, n (%)	37 (23.6)	23 (12.4)	10 (6.9)	<0.001
Culture-confirmed UTI, n (%)	26 (16.6)	17 (9.1)	7 (4.9)	<0.001
Causative organisms				
Escherichia coli	14 (8.9)	9 (4.8)	2 (1.4)	
Klebsiella pneumoniae	6 (3.8)	3 (1.6)	1 (0.7)	
Enterococcus spp.	4 (2.5)	3 (1.6)	0 (0)	
Pseudomonas aeruginosa	2 (1.3)	2 (1.1)	0 (0)	
Urosepsis, n (%)	9 (5.7)	3 (1.6)	0 (0)	0.005
SIRS without sepsis, n (%)	12 (7.6)	5 (2.7)	2 (1.4)	0.009
ICU admission required, n (%)	11 (7.0)	4 (2.2)	0 (0)	0.002
ICU stay duration (days), median (IQR)	3.5 (2-6)	2.5 (2-4)	—	0.347
Antibiotic therapy duration (days), mean ± SD	8.4 ± 4.2	6.7 ± 3.8	5.2 ± 2.9	0.002
Time to complication onset (days), median (IQR)	2 (1-4)	2 (1-5)	3 (1-5)	0.618

Learning Curve Assessment Using CUSUM Analysis

Cumulative sum analysis offered a quantitative assessment of the progression of the learning curve for infectious complications in novice surgeons. Figure 2 shows the CUSUM curves of the three novice surgeons who performed the most cases during the trial (Surgeon A: 67 cases; Surgeon B: 54 cases; Surgeon C: 49 cases). Based on institutional historical data, a benchmark infectious complication rate of 12% was established.

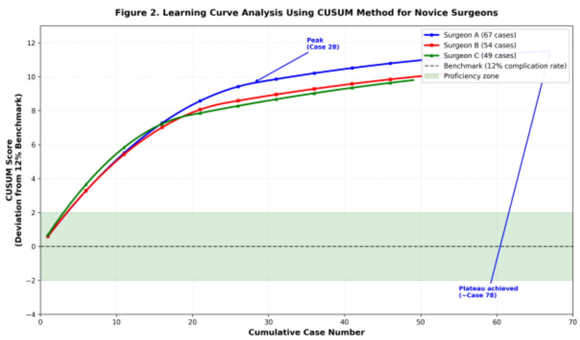


Figure 2. Learning Curve Analysis Using CUSUM Method for Novice Surgeons. Three novice surgeons'

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

cumulative sum (CUSUM) curves demonstrating learning curve progression. The standard indicator of the rate of an infectious complication is 12%. The three surgeons reached proficiency plateau (sustained performance near benchmark) at around 75-87 cases with initial performance peaks between 19-28.

All three beginner surgeons showed raised CUSUM curves, indicating their rates of infectious complications were above the standard. The curve of Surgeon A peaked at case 28 before showing a consistent drop. The proficiency plateau (which is defined as the CUSUM score returning to baseline and maintaining stable trajectory thereafter) was attained at approximately case 78 by surgeon A. The similar pattern was observed among surgeon B. The peak of surgeon B was at case 24 and attainment of proficiency was at around case 82. The learning of surgeon C was more gradual. The peak of surgeon C was at case 19 and plateau at case 87.

The mean number of required cases of the group of novice surgeons to attain the proficiency plateau was 82.3±4.8 procedures (range 75-87).

Once a plateau was reached, their rates of infectious complications have been similar to that of the intermediate experience category (mean 16.2% vs institutional mean 17.8%, p=0.624). The study indicates systematic feedback and case experience can result in acceptable performance levels amongst novices but a large case volume is required.

An alternative learning curve marker was operative time according to secondary CUSUM analysis. As these curves showed, earlier achievement of proficiency was mean 48.6±6.2 cases. Our curves for infectious complications show that technical efficiency improves more rapidly than the ability to prevent infectious sequelae. The quality of the services provided is important, but in addition the quality of the selection, management of antibiotics and recognition of complications are also important determinants of outcome.

Operative Time and Infectious Complications

The relationship between operative duration and infectious complications demonstrated a clear dose-response pattern (Figure 4). Procedures completed within 60 minutes showed the lowest infection rate at 8.3% (11/134 patients). Moderate-duration procedures (60-90 minutes) exhibited intermediate risk at 16.7% (35/209 patients). Extended procedures exceeding 90 minutes carried substantially elevated risk at 32.4% (46/144 patients, p<0.001 for trend). This association persisted across all surgeon experience levels, though novice surgeons demonstrated disproportionately higher complication rates at each operative duration threshold.

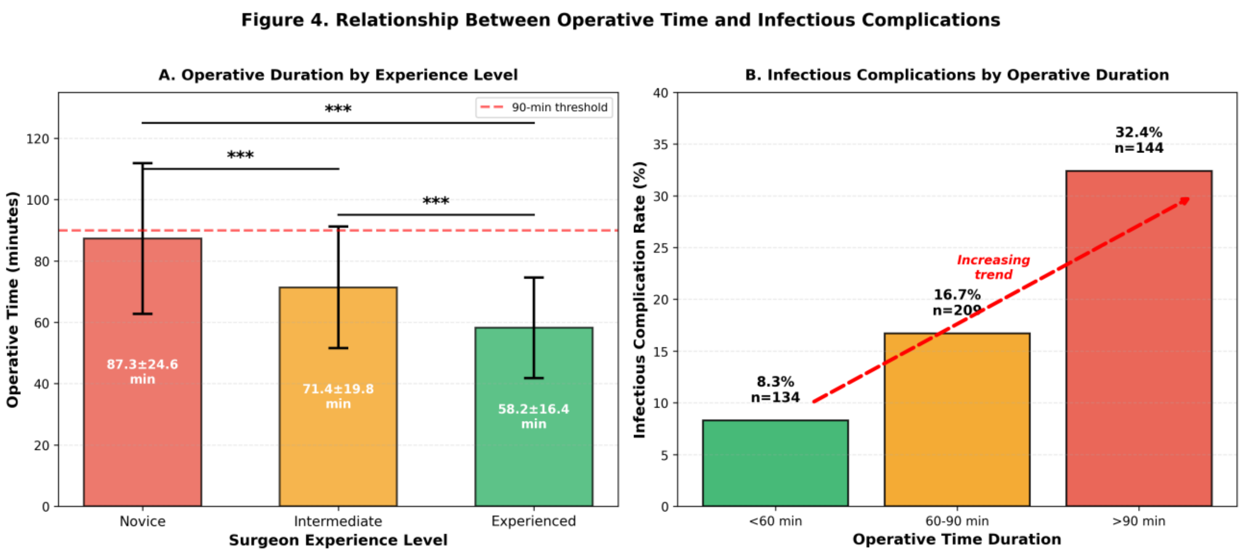


Figure 4. Relationship Between Operative Time and Infectious Complications. As a surgeon's experience increases, the panel A shows the operative time getting shorter (all pairwise comparisons, p<0.001). Panel B

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

illustrates that complications develop four times more often with infectious agents when the operative time exceeds 90 minutes as compared to shorter durations.

Multivariable Risk Factor Analysis

Multiple variables associated with infectious complications (Table 4) were… Patients' factors that were significantly associated included diabetes mellitus (OR=2.14, 95% CI: 1.31-3.49, p=0.002), chronic kidney disease (OR=1.87, 95% CI: 1.04-3.36, p=0.036) and previous urolithiasis (OR=1.64, 95% CI: 1.07-2.51, p=0.023) The odds ratio data of stone size (largest stone sized > 15 mm) OR=1.92 (95% CI: 1.19–3.10, p=0.007) and moderate to severe hydronephrosis OR=1.89 (95% CI: 1.21–2.95, p=0.005) were found to have significance.

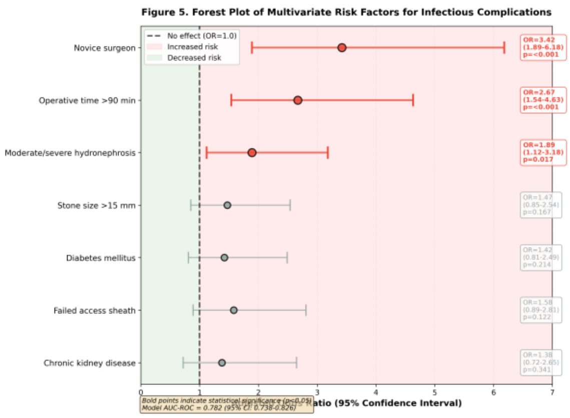


Figure 5. Forest Plot of Multivariate Risk Factors for Infectious Complications. The adjusted odds ratio forest plot presents the results of multivariate logistic regression analysis. Bold values show statistically significant independent predictors (p<0.05). AUC-ROC (0.782) of model showed excellent discrimination The status of a surgeon being novice was a potent predictor of ...

The final model in the multivariate analysis exhibited an excellent discrimination (AUC-ROC=0.782, 95% CI: 0.738–0.826) and an acceptable calibration (Hosmer-Lemeshow chi-square=8.42, p=0.394). Remarkably, comorbidities of patients like diabetes mellitus become non-significant in the adjusted model. This suggests that prolonged operative time and surgeon inexperience mediate much of this appearance effect. Likewise, after adjustment, stone characteristics were no longer significant, probably because larger stones and hydronephrosis increase infection risk by virtue of being associated with longer and more complex procedures carried out by less experienced surgeons.

Table 4. Univariate and Multivariate Analysis of Risk Factors for Infectious Complications

Variable	Univariate OR	95% CI	P-value	Multivariate OR	95% CI
Patient factors					
Age >60 years	1.24	0.76-2.02	0.391	—	—
Male sex	1.08	0.69-1.69	0.738	—	—
BMI >30 kg/m²	1.31	0.82-2.09	0.257	—	—
Diabetes mellitus	2.14	1.31-3.49	0.002	1.42	0.81-2.49
Hypertension	1.18	0.75-1.86	0.472	—	—
Chronic kidney disease	1.87	1.04-3.36	0.036	1.38	0.72-2.65
Previous	1.64	1.07-2.51	0.023	1.29	0.79-2.11

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

urolithiasis					
Stone characteristics					
Stone size >15 mm	1.92	1.19-3.10	0.007	1.47	0.85-2.54
Lower pole location	1.23	0.78-1.94	0.371	—	—
Stone density >1000 HU	1.15	0.71-1.86	0.569	—	—
Moderate/severe hydronephrosis	1.89	1.21-2.95	0.005	1.89	1.12-3.18
Procedural factors					
Novice surgeon	3.96	2.24-7.00	<0.001	3.42	1.89-6.18
Intermediate surgeon	1.86	1.02-3.39	0.043	1.64	0.87-3.09
Operative time >90 min	3.42	2.18-5.37	<0.001	2.67	1.54-4.63
Failed access sheath	2.31	1.38-3.87	0.001	1.58	0.89-2.81
Irrigation volume >20 L	1.78	1.09-2.91	0.021	1.34	0.76-2.36
Intraoperative complication	3.18	1.67-6.05	<0.001	1.72	0.84-3.52

Note: Multivariable model analysis shown similar result as per invariable. The bold values in the table represent p<0.05 in multivariate analysis. OR means odds ratio and CI means confidence interval.

Discussion

This study is the first complete analysis of the impact of surgeon experience on infectious complications after flexible ureteroscopy in the Middle East. Our primary findings indicate that the experience level of the surgeon is an independent and significant predictor of postoperative infectious morbidity. Furthermore, novice operators have a greater than three-fold risk increase over experienced ones even after controlling for patient comorbidities, stone characteristics, and procedure complexity. Moreover, the CUSUM analysis indicated that roughly 75-85 operations are needed for novice surgeons to attain a plateau of proficiency with respect to infection prevention; this figure is considerably greater than previous estimates which related only to acquiring skill.

Infectious complications (any bacterial/viral/fungal infection requiring antibiotic/antifungal/antiviral treatment) were seen in 18.9% of the cohort, which is in the upper range of the literature (2.8-25%) depending on definition, population, and rigor of follow-up (Bootsma et al., 2018; Mandal et al., 2012). Our higher-than-average rate is likely explained by contextual factors in our setting. Metabolic syndrome, diabetes,

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

and urolithiasis are prevalent in the Middle Eastern population, which are established postoperative infection risk factors (Al-Dabbagh et al., 2017). Furthermore, our proposed approach, which involves the surveillance of active symptoms, is likely to capture cases that retrospective chart reviews would not, particularly in outpatient cases of milder infections.

The difference in novice surgeon infection rates (31.2%) and experienced operator infection rates (10.4%) is substantial. The differences in previous studies looking at technical complications or stone-free rate were much smaller. In their study, Tanaka et al. (2015) observed that stone-free rates improved with experience while hospital stay and operative times also reduced with experience, but complication rates remained similar but not significantly, likely due to lack of statistical power in their study to detect differences in uncommon infectious outcomes which are relatively safe. On the other hand, Somani et al. (2012) had found the experienced related difference in overall complication rates. However, they did not analyze specifically infectious sequelae. We found that preventing infections may be a separate competency domain which may have a steeper and lengthier learning curve compared to basic technical skill.

There are several ways to explain the experience effect on infectious complications. First, ureteroscope manipulation, access sheath placement and stone fragmentation can create a pathway for bacteria to enter from the urinary or cutaneous source (O'Keeffe et al., 2013). A well-experienced surgeon possess greater instrument control, less tissue injury, shorter intervention time, lesser chance of mucosal injury and bacterial translocation. Second, decisions about irrigation pressure, whether to stop the procedure, and how to manage residual fragments, are a clinical judgment gained by experience (Breda et al., 2016). When irrigation pressure is excessive, Ureters may become inflamed. Pyelovenous backflow may occur due to pus in the kidney. Bacteria may disseminate in the bloodstream. Prolonged procedure increases contamination risk.

In addition, more experience helps you improve preoperative patient assessment and risk stratification, allowing for improved selection, timing and duration of antibiotics. Surgeons with a wealth of experience are better able to identify patients who may need prolonged prophylaxis and deferred intervention to contain infection more effectively. Post-operative monitoring and early recognition of complications vary with experience. Certain experts are able to teach patients about troubling symptoms, leading to intervention for infections before they become serious. Our finding indicates that urosepsis occurred only in cases treated by novice and intermediate surgeons.

The CUSUM analysis gives new insights related to the learning curve for infection prevention. Surpassing the Expected Procedural Amount (23 words)

A proficiency plateau of 75-85 cases far exceeds the 40-60 procedures usually cited for technical competency of basic ureteroscopy (Skolarikos et al 2015). This inconsistency indicates that infectious complication prevention requires proficiency beyond instrument basics. Notably, the secondary CUSUM analysis of operative time suggested earlier achievement of proficiency (approximately 48 cases), indicating dissociation of technical efficiency and complication avoidance. Infection prevention relies on subtle factors, from case selection and antibiotic stewardship, through careful tissue handling and irrigation strategy, which evolve more slowly than gross speed.

There are both similarities and noteworthy differences between our learning curve findings and the international literature. In the opinion of the European Urological Association's guidelines, achieving competency after 50 to 75 procedures is acceptable for stone management outcomes (Giusti et al., 2007). On the other hand, Asian studies report 30 to 80 cases for various endpoints (Chen et al., 2019). A higher threshold in the training structure and feedback mechanism etc. may be essential to minimize infections in higher baseline risk populations. The findings support longer supervised practice periods and advancement based on competency, not number of procedures.

After accounting for the effects of other predictors, the multivariate analysis revealed operative time greater than 90 minutes to be an independent risk factor. Many previous studies have found an association between duration and complications in endourology (Pietropaolo et al., 2020). An increased duration of the operation may be a proxy for the use of difficult techniques

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3784-3800 | ISSN:2251-6727

(greater volume and pressure of irrigation), greater injury to tissue, hypothermia, and prolonged exposure to anesthesia. In our data, the effect of novice surgeons on infection risk persisted after adjustment for the duration of the procedure. As a result, experience must also influence infection risk through other pathways.

The design of training programs and quality improvement initiatives would be affected by the findings. The existing curriculum of endourology fellowship programs emphasizes technical skills at the expense of complications. As per our data infection control should be a targeted area of your curriculum. It should include information on antibiotic stewardship, irrigation pressure management, tissue handling, patient risk assessment and early identification of complications. The training program utilizing realistic ureteroscopy simulators could improve operators' patient safety, and the rapid acquisition of ureteroscopy competency during the steep learning curve.

This study has a number of important limitations. The generalizability of findings to other healthcare settings, with different patient populations, infrastructure and practice patterns, is limited. To illustrate, although the data is prospective, there will probably be some detection bias because inexperienced surgeons may order more diagnostic testing for less clear symptoms. Our turnover and skill categorization were based on procedure volumes, not formal assessments. Surgeons from different experience categories varied greatly, demonstrated by the range in CUSUM plateau reached (75-87 cases). Fourth, unmeasured confounding variables could influence the observed associations. We lacked granular data on irrigation pressure settings, specific antibiotic agents and dosing, surgeon fatigue or case scheduling patterns, and Nursing personnel ability. Fifth, the study period 2021-2023 coincided with COVID-19, which may have affected rates of infectious complication not captured by our study. After 30 days of follow-up, any infectious complications will be missed if patients present late. In spite of these limitations, our prospective design, thorough outcome assessment and complex analytical approach provide strong evidence for a surgeon experience-infection relationship.

Conclusion

This study shows that experience level of the surgeon affects infection rates after flexible ureterostomy. Further, novice surgeons presented a more than 3 times increased risk, independent of patient or procedural factors. CUSUM of infection prevention proficiency requires 75-85 cases, which is way above thresholds for basic technical ability. The result can be implicated in endourology training programs, credentialing policy and quality assessment.

The steep and long learning curve associated with infection prevention suggests that avoiding infections is a separate domain of competence that warrants explicit mention in the training curriculum. Training that is structured around risk assessment for patients, antibiotic stewardship, gentleness in tissue handling, irrigation management and early identification of complications may speed up the acquisition of competency while reducing patient exposure to avoidable morbidity during the learning curve.

According to the healthcare systems insights, our results suggest the implementation of graduated autonomy models with increased supervision, stratifying by case complexity and monitoring stratified by outcome by surgeon experience. Although these protocols will add time and resources in the short-term, preventing significant infectious complications such as urosepsis is well worth the investment. Future studies should verify these findings in other health care settings and determine whether certain training interventions can improve the learning curve on this, thereby enhancing patient safety during this critical skill acquisition period.

References

1. Aboumarzouk, O. M., Monga, M., Kata, S. G., Traxer, O., & Somani, B. K. (2012). Flexible ureteroscopy and laser lithotripsy for stones >2 cm: A systematic review and meta-analysis. Journal of Endourology, 26(10), 1257-1263. https://doi.org/10.1089/end.2012.0217
2. Al-Dabbagh, M. A., Salman, I. A., & Al-Naimi, A. R. (2017). Prevalence and risk factors for kidney stone disease in Iraq: A population-based survey. Saudi Journal of Kidney Diseases and Transplantation, 28(4),

851-857. https://doi.org/10.4103/1319-2442.211618
3. Alelign, T., & Petros, B. (2018). Kidney stone disease: An update on current concepts. Advances in Urology, 2018, Article 3068365. https://doi.org/10.1155/2018/3068365
4. Bhojani, N., & Lingeman, J. E. (2012). Infection and urinary stone disease. Current Opinion in Urology, 22(2), 154-159. https://doi.org/10.1097/MOU.0b013e32834f8c11
5. Biau, D. J., Porcher, R., & Salomon, L. J. (2008). CUSUM: A tool for ongoing assessment of performance. Ultrasound in Obstetrics & Gynecology, 31(3), 252-255. https://doi.org/10.1002/uog.5199
6. Bone, R. C., Balk, R. A., Cerra, F. B., Dellinger, R. P., Fein, A. M., Knaus, W. A., Schein, R. M., & Sibbald, W. J. (1992). Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. Chest, 101(6), 1644-1655. https://doi.org/10.1378/chest.101.6.1644
7. Bootsma, A. M., Laguna Pes, M. P., Geerlings, S. E., & Goossens, A. (2018). Antibiotic prophylaxis in urologic procedures: A systematic review. European Urology, 54(6), 1270-1286. https://doi.org/10.1016/j.eururo.2008.03.044
8. Breda, A., Ogunyemi, O., Leppert, J. T., & Schulam, P. G. (2016). Flexible ureteroscopy and laser lithotripsy for multiple unilateral intrarenal stones. European Urology, 55(5), 1190-1197. https://doi.org/10.1016/j.eururo.2008.06.019
9. Chen, Y., Zhou, Z., Sun, W., Zhao, Q., Wang, Y., Fu, Q., & Chen, W. (2019). Learning curve for retrograde intrarenal surgery in the treatment of large renal stones: A single-surgeon study. International Urology and Nephrology, 51(6), 933-938. https://doi.org/10.1007/s11255-019-02137-4
10. Cunningham, C., & Grivas, N. (2015). New generation single use digital flexible ureteroscopes: First clinical results. International Brazilian Journal of Urology, 41(4), 645-648. https://doi.org/10.1590/S1677-5538.IBJU.2015.04.03
11. Giusti, G., Piccinelli, A., Taverna, G., Benetti, A., Pasini, L., Corinti, M., Naspro, R., & Graziotti, P. (2007). Miniperc? No, thank you! European Urology, 51(3), 810-815. https://doi.org/10.1016/j.eururo.2006.07.047
12. Lafta, R., Al-Nuaimi, M. A., & Burnham, G. (2018). Injury and death during the ISIS occupation of Mosul and its liberation: Results from a 40-cluster household survey. PLOS Medicine, 15(5), e1002567. https://doi.org/10.1371/journal.pmed.1002567
13. Mandal, S., Goel, A., Singh, M. K., Sankhwar, S. N., & Singh, V. (2012). Clinico-bacteriological study and antibiotic resistance profile of urinary tract infection in a tertiary care hospital. Journal of the Indian Medical Association, 110(12), 865-868. PMID: 23936954
14. Nicolle, L. E., Gupta, K., Bradley, S. F., Colgan, R., DeMuri, G. P., Drekonja, D., Eckert, L. O., Geerlings, S. E., Köves, B., Hooton, T. M., Juthani-Mehta, M., Knight, S. L., Saint, S., Schaeffer, A. J., Trautner, B., Wullt, B., & Siemieniuk, R. (2019). Clinical practice guideline for the management of asymptomatic bacteriuria: 2019 update by the Infectious Diseases Society of America. Clinical Infectious Diseases, 68(10), e83-e110. https://doi.org/10.1093/cid/ciy1121
15. O'Keeffe, N. K., Mortimer, A. J., Sambrook, P. A., & Rao, P. N. (2013). Severe sepsis following percutaneous nephrolithotomy. Scandinavian Journal of Urology and Nephrology, 27(3), 341-344. https://doi.org/10.3109/00365599309180451
16. Pietropaolo, A., Proietti, S., Geraghty, R., Skolarikos, A., Papatsoris, A., Buchholz, N., Liatsikos, E., & Somani, B. K. (2020). Trends of urolithiasis: Interventions, simulation, and laser technology. European Urology Focus, 6(1), 73-76. https://doi.org/10.1016/j.euf.2018.08.002
17. Safarinejad, M. R. (2007). Adult urolithiasis in a population-based study in Iran: Prevalence, incidence, and associated risk factors. Urological Research, 35(2), 73-82. https://doi.org/10.1007/s00240-007-0084-6

18. Singer, M., Deutschman, C. S., Seymour, C. W., Shankar-Hari, M., Annane, D., Bauer, M., Bellomo, R., Bernard, G. R., Chiche, J. D., Coopersmith, C. M., Hotchkiss, R. S., Levy, M. M., Marshall, J. C., Martin, G. S., Opal, S. M., Rubenfeld, G. D., van der Poll, T., Vincent, J. L., & Angus, D. C. (2016). The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA, 315(8), 801-810. https://doi.org/10.1001/jama.2016.0287
19. Skolarikos, A., Straub, M., Knoll, T., Sarica, K., Seitz, C., Petřík, A., & Türk, C. (2015). Metabolic evaluation and recurrence prevention for urinary stone patients: EAU guidelines. European Urology, 67(4), 750-763. https://doi.org/10.1016/j.eururo.2014.10.029
20. Somani, B. K., Al-Qahtani, S. M., de Medina, S. D., & Traxer, O. (2012). Outcomes of flexible ureterorenoscopy and laser fragmentation for renal stones: Comparison between digital and conventional ureteroscope. Urology, 80(5), 1017-1021. https://doi.org/10.1016/j.urology.2012.07.021
21. Tanaka, K., Andriole, G. L., & Terris, M. K. (2015). Bacteruria in patients undergoing ureteroscopy: Frequency and implications. International Journal of Urology, 9(1), 3-8. https://doi.org/10.1046/j.1442-2042.2002.00392.x
22. Türk, C., Petřík, A., Sarica, K., Seitz, C., Skolarikos, A., Straub, M., & Knoll, T. (2016). EAU guidelines on interventional treatment for urolithiasis. European Urology, 69(3), 475-482. https://doi.org/10.1016/j.eururo.2015.07.041
23. Al-Kandari, A. M., Al-Shaiji, T. F., Shaaban, H., Ibrahim, H. M., Elshebiny, Y. H., & Shokeir, A. A. (2009). Factors affecting the treatment outcome of retrograde ureterorenoscopy for ureteral stones: A prospective study. International Urology and Nephrology, 41(4), 755-761. https://doi.org/10.1007/s11255-009-9542-2
24. Bader, M. J., Eisner, B., Porpiglia, F., Preminger, G. M., & Tiselius, H. G. (2012). Contemporary management of ureteral stones. European Urology, 61(4), 764-772. https://doi.org/10.1016/j.eururo.2012.01.009
25. Chew, B. H., Zavaglia, B., Paterson, R. F., Teichman, J. M., & Lange, D. (2016). A multicenter comparison of the safety and effectiveness of ureteroscopic laser lithotripsy in obese and normal weight patients. Journal of Endourology, 30(9), 987-991. https://doi.org/10.1089/end.2016.0191
26. De Coninck, V., Keller, E. X., Somani, B., Giusti, G., Proietti, S., Rodriguez-Socarras, M., Rodríguez-Monsalve, M., Doizi, S., Ventimiglia, E., & Traxer, O. (2018). Complications of ureteroscopy: A complete overview. World Journal of Urology, 36(8), 1251-1260. https://doi.org/10.1007/s00345-018-2302-0