The Predictive Factors for Complications of Semi-Rigid Ureteroscopy Using Holmium YAG Laser Lithotripsy

Nooman H. Saeed*, Zaid S. Khudhur*, Uday H. Mohammad*

ABSTRACT

Although laser lithotripsy has improved the efficacy of ureteroscopic management of ureteric stones, significant complications still occur. Several factors were found to be associated with the occurrence of such complications. To predict the factors that might be associated with complications during ureteroscopy using laser stone fragmentation. A retrospective study (Jan 2022–Sep 2025) and a prospective study(Jan 2022–Sep 2025) were performed on 1073 patients with stones in the ureters recruited from multiple hospitals in Mosul City (Iraq). Clinical assessment of the patient's condition was conducted, focusing on postoperative complications. Among the study sample, the overall complications were 4.8%. The most frequent complications were mucosal tear in 33.3% and postoperative fever in 23.5%. Most of the patients with complications were males, and the stone was located on the left side, with no statistically significant differences. Significant differences were found concerning the presence of ureteric abnormality (stricture, stenosis or ureteric kink), the stone diameter, ureteric stone location, the number, and the diameter of the ureteroscope used. The complications were low with no gender discrepancy, but several factors, such as the presence of ureteric abnormalities, diameter of the stone more than 10 mm, presence of multiple stones, stones in the proximal part of the ureter, together with using the larger size ureteroscopes, were associated with higher frequencies of complications.

Keywords: Complications, Holmium YAG laser, Lithotripsy, Semi-rigid ureteroscopy.

INTRODUCTION

With the new lifestyle and dietary habits changes, weight gain, and increased chronic medical illnesses, ureteric calculi became more common[1]. These calculi, when untreated, might end up with renal impairment and even failure[2,3]. Urinary calculi are the 3rd pathology that affects the urinary tract[4]. Management of stones in the ureter varies from medical expulsive therapy and spontaneous stone passage to the usage of fine endoscopic instruments with minimal invasion, which provides little pain and a fast healing and discharge home. Ureteroscopic stone treatment (URL) is becoming the preferred modality of treatment for more distal ureteric calculi owing to its safe and effective results[5]. Stone fragmentation using Laser has become a universal and preferred procedure of management for stones in the urinary tract[6]. Holmium: YAG laser lithotripsy has progressively improved the effectiveness of treatment of calculi in the ureters[7]. The use of ureteroscopy for the treatment of ureteric stones is a procedure with special technical demands[8]. Using a laser for intracorporeal stone fragmentation is a safe procedure, with the most frequent complication of its use being ureteric wall injury near the site of the stone[9].

The complications of ureteroscopic laser stone fragmentation can vary and are influenced by several predictive factors. Some common factors that may contribute to complications during this procedure include:

Stone size and complexity: Larger or complex stones can increase the difficulty of the procedure and may be associated with more complications[10].

Stone location: Upper ureteric stones may be more challenging to reach and treat, together with more possible complications.

Previous urological surgery: Previous urological interventions may lead to altered anatomy or scar tissue that can make the procedure more complicated and increase the risk of complications[10,11].

Anatomical variations: These anatomical variations can make the surgical intervention more challenging and result in a greater potential risk of injuries and complications.

Patient factors: Patient-related factors such as age, overall health, and the presence of conditions like diabetes or hypertension can influence the risk of complications during the procedure[12].

Experience of the Surgeon: The experience and skill of the surgeon performing the procedure have an important impact on determining the outcome of the procedure.

Equipment: Type and quality of equipment used during the procedure, including the laser lithotripter and endoscopic instruments, can impact the risk of complications[10,11].

Intraoperative complications: Factors such as bleeding and perforation during the procedure result in more postoperative complications.

Postoperative care: The quality of postoperative care, including monitoring for complications such as infection or urinary retention, can impact the overall outcome of the procedure[13].

The complications that occur due to ureteroscopic interventions can, in general, be stratified into two main types: Systemic complications like sepsis, which occur in 2.38% of the procedure, and result in a death rate of about (0.06%). And local complications, like ureteric injury and avulsion[14]. Much literature has identified factors related to complications of ureteroscopic intervention. Some of these are related to the patient and the stone condition, like the more proximal stone location, the stone burden, gender, older patients, the presence of chronic diseases (which are calculated by the Charlson comorbidity index), history of surgical intervention, stone impaction,

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and emergency conditions. Other complications are related to operator experience, type of anaesthesia, and the procedure time[15,16], where interestingly, as reported in literature, the operative time is related to the overall complications and significantly associated with more ureteral injuries (p=0.0005)[17]. The objective of this study was to identify the predictive factors for complications associated with the use of semi-rigid ureteroscopy using Holmium YAG laser lithotripsy.

PATIENTS AND METHODS

A retrospective and prospective study that included 1073 cases who consulted multiple hospitals in Mosul city, who were suffering from ureteric stones in the period between Jan 2022 and Sep 2025. Patient's evaluation started with a history with special concentration on urinary tract stone diseases in the past and how they were managed, and whether complications were encountered during previous surgical interventions. After physical examination, the laboratory investigations were performed and included urine analysis, renal function test, Hb, and other tests depending on each individual's condition. Imaging studies included urinary tract ultrasound, contrast computed tomography of kidneys, ureters, and bladder and/or intravenous urography or CT scan to evaluate the urinary tract and the stones. Infections of the urinary tract were treated properly according to culture and sensitivity results before any intervention.

Conditions that were indicated for surgical interventions had a detailed discussion of the procedure to be performed, including the expected outcome and the potential complications that might occur after a consent form was signed for each patient.

The same protocols were followed in all of the surgical interventions. Semirigid 7Fr and/or 9.5Fr (Karl Storz) ureteroscopes were used. A ureteric stent is inserted into the ureteric orifice and followed by the ureteroscope. Stone fragmentation and dusting were achieved using a Holmium YAG laser (Ho: YAG). Stones that start to be pushed back were grasped or fixed by the Dormia basket or other instruments to decrease the possibility of stone migration to the kidneys. Stone dust and tiny stone fragments were allowed to pass spontaneously by irrigation, and bigger size fragments were gently removed using Dormia's basket or forceps.

Finally, the choice of insertion of JJ stent depended on multiple factors like the presence of complications, the condition of the ureter, the ipsilateral and the contralateral kidney, whether there are residual renal or ureteric calculi, and the overall condition of the patient.

The vast majority of cases were day case procedures and were discharged home on the same day of intervention. They were informed to check urine output, looking for passage of stones or gravel, and the presence of macroscopic hematuria, with later reevaluation of the patients using imaging studies. Those who were identified to have complications were usually kept overnight or even longer till their conditions were settled. Data were tested for normalisation using the Shapiro-Wilk test. When complications happened, they were documented with their details for each procedure and reported using a standard form. The statistical analysis used was to compare Patients with complete stone clearance without documented complications with those who had complications by using t-tests. and were used. SPSS 15 for Windows (Chicago, II) was used for statistical analysis. Pearson's chi-square tests were performed. A p-value of less than 0.05 was considered statistically significant.

Table 1. Patients' demographic and clinical data of participants.

Patients' data		Frequency
Age (years)		5-73 (39±17)
Gender	**Male**	652(60.8)
	Female	421(39.2)
Laterality	**Left**	582(54.2)
	Right	478(44.6)
	Bilateral	13(1.2)
Stones location	**Upper**	380(35.4)
	Mid	208(19.4)
	Lower	485(45.2)
Stone size (4-26mm)	**1-10 mm**	975(90.8)
	>10 mm	98(9.2)

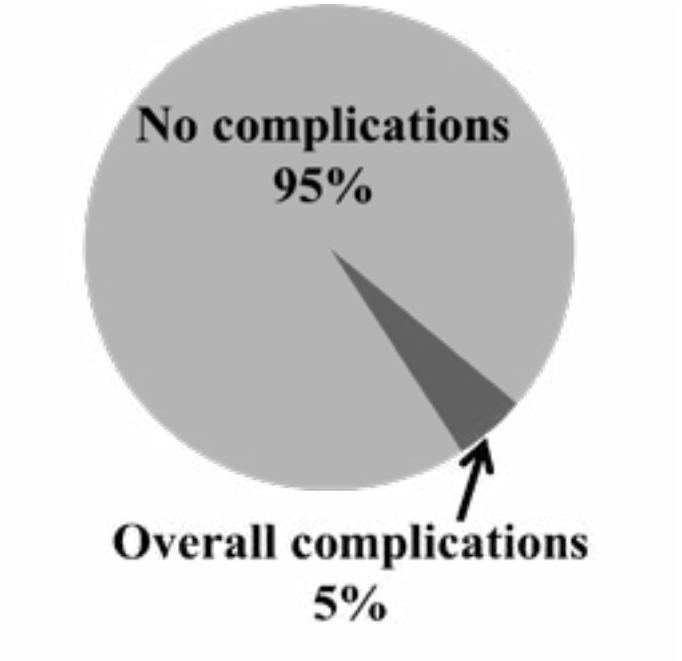

Figure 1. The overall complication rates in the studied groups.

RESULTS

The study involved 1073 patients. The patients' age in years ranged between 5 and 73 years, with a mean±SD of 39±17 years, with 652 males (60.8%) and 421 females (39.2%). Left-sided stones were found in 582 patients (54.2%), right-sided stones in 478 patients (44.6%), and bilateral stones in 13 patients (1.2%). Regarding stone location in the ureters, there were 380 patients (35.4%) with upper ureteric stones, 208 patients (19.4%) with mid ureteric stones, and 485 patients (45.2%) with lower ureteric stones. Stone sizes ranged from 4 to 26 mm in their longest diameter. Of those 975(91.0%) stones were 10mm or less, 19(1.9%) patients had complications, and 98(9.0%) stones were >10mm; of them, 32(32%) patients had complications (Table 1).

The percentage of overall complications was illustrated in Figure 1, which showed that complications were reported in 4.8% among the study sample.

The distribution of the patients with complications related to the site of ureteric calculi was illustrated in Figure 2 and showed that overall complications were reported in 51 patients (4.8%) distributed as upper: 380 (35.4%) with complications: 23 (6.1% of the upper ureteric stones patients), the mid: 208 (19.4%) with complications: 8 (3.8%) of the mid ureteric stones patients), and lower: 485 (45.2%) with complications: 20 (4.1% of the lower ureteric stones patients).

Complications demonstrated in (Table 2) show that the most frequent complication was mucosal tear in 17(33.3%), 14 patients out of them

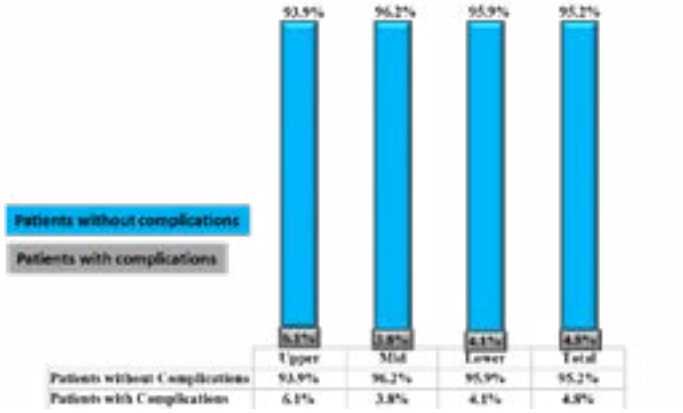

Figure 2. The distribution of the patients with complications according to the ureteric site of calculi.

had ureteric abnormalities, postoperative fever in 12(23.5%), 6 patients out of them had ureteric abnormalities, and ureteric perforation in 3(5.9%), and all of them had ureteric abnormalities.

Data confirmed that 49.0% of the complications were found among males, while 51.0% found in females (p= 0.078). Table 3 demonstrated that 56.8% of the patients with complications and 16.8% of the patients without complications were found to have abnormal ureteric status, while 43.2% and 83.2% of patients with and without complications had no abnormal ureteric status, respectively (p=0.000). Findings revealed that complications in those patients with left-sided ureteric stones were slightly more frequent than the right side (p=0.564). Results reported 62.9% of patients with complications reported calculi of more than 10 mm in diameter, and 37.2% of those with calculi of 10 mm or less reported complications (p=0.000). Assessment for the site of ureteric calculi revealed that 52.9% of the complications were reported with upper ureteric stones, 31.4% with mid ureteric stones, and 15.7% with lower ureteric stones (p=0.000). Results demonstrated that 31.4% of patients with complications had multiple ureteric calculi, while 68.6% of them had single ureteric calculi; the difference in relation to patients without complications had statistical significance (p=0.000). Among the complications, 92% of patients with complications were operated on using a 9.5Fr ureteroscope in comparison to 8% of patients with complications operated on using a 7Fr ureteroscope (p=0.017).

DISCUSSION

The ultimate goal of management of ureteric calculi is to be stone-free with the least possible complications[17]. Complication rate were 4.8% of the cases involved, which was similar to results presented in previous studies, which was 4.0% in Esposito *et al.*[18], 2.4% in Tiryaki *et al.*[19], and 4.8% in Erturhan *et al.*[20]. Although in some other articles, complication rates were different and reported to be up to 42.0% in Bayar *et al.* study[21], 46.0% in Ozkan *et al.* study[22], and up to 57.9% in Öğreden *et al.* study[23]. These discrepancies compared to our study are potentially related to the fact that more than 90% of stone sizes in the present study were lower than 10mm; however, the higher rate of complications associated with stone sizes larger than 10mm.

The presence of abnormal ureteric status (Ureteric stricture/kink or mucosal inflammation at the site of impacted stone) was significantly associated with the development of complications among the present study sample. Shen *et al.*[24] and Li *et al.*[25] studies demonstrated that patients with significant hydronephrosis had higher rates of ureteric strictures. Moreover, Yoshida *et al.*[26] found in their study that by using multivariate analysis, the abnormal ureteric status (ureteral wall thickness) was an independent predictor of impacted stones and subsequent complications (odds ratio 5.43, P <0.001).

Semi-rigid ureteroscopy is commonly used for treating ureteric calculi with a high success rate[22]. The improvement of treating stone in the ureters belongs to the progressive technical advancement of the ureteroscopic design, together with improvement in the options of stone fragmentation, including laser lithotripsy[27]. Miniaturisation of the size of the ureteroscope (7Fr vs 9.5 and 10Fr) was associated with a lower complication rate (p=0.017). This result was comparable with the previous studies[28]. It is worth mentioning that the 9.5Fr ureteroscope was overall more frequently used, and this might affect the results. On the contrary, the Demirelli *et al.* study[29] reported no significant difference in using the 7 Fr and 9 Fr ureteroscopes.

Among the patients of the present study with complications, the mucosal tear was the most frequently reported complication, accounting for 33.3%, followed by post-operative fever and stone migration. The more frequent use of instruments for removal of stone fragments, like Dormia's basket and forceps, might be associated with more frequent reteric traumas, the stone fragmentation to tiny pieces might omit the use of additional instruments and improve the stone-free rate[30]. In the present study, using a smaller size ureteroscope (7Fr.), which is less traumatic, especially at introduction to the ureteric orifice, was associated with fewer complications, where mucosal tear occurs when trying to introduce the ureteroscopes, and at introduction of other accessory instruments[31]. Tepeler *et al* found that the mucosal injury was the second most frequent complication after the proximal stone migration[28].

In the current study, the difference between males and females revealed no statistical significance, which was similar to the result reported by the Demirelli *et al.* study[29]. While in Öğreden *et al.*study, more

Table 2. Comparison between rates of different types of complications based on gender.

Complications	Male n=36		Female n=15		Total n=51
	No.(%)	Ureteric abnormality	No.(%)	Ureteric abnormality	No.(%)
Mucosal tear	8(22.2)	7(87.5)	9(60.0)	7(77.8)	17(33.3)
Postoperative fever	5(13.9)	2 (40.0)	7(46.7)	4(57.1)	12(23.5)
Stone migration (pushed back) to the kidneys	3(8.3)	------	4(26.7)	------	7(13.7)
Postoperative hematuria	3(8.3)	------	2(13.3)	------	5(9.8)
Ureteric perforation	2(5.6)	2 (100.0) DM	1(6.7)	1(100.0) pregnant	3(5.9)
Inability to reach the stone due to a ureteric kink or stricture	2(5.6)	2(100.0)	1(6.7)	1(100.0)	3(5.9)
Postoperative sepsis	-	------	1(6.7)	------	1(1.9)
Pelvic perforation	1(2.8)	1 (100.0) with pyonephrosis	-	------	1(1.9)
Perinephric hematoma	1(2.8)	1(100.0)	1	1(100.0)	2 (3.8)

Table 3. Comparison between complication rates based on patient factors in the studied groups.

Patients parameters		Complications, n(%)	Without complications, n(%)	p-value
Patients' gender	**Female**	26 (51.0)	395(38.6)	0.078*
	Male	25 (49.0)	627(61.4)	
Ureteric stricture/kink or mucosal inflammation at the site of the impacted stone	**Present**	29(56.8%)	172(16.8%)	**0.000***
	Absent	22(43.2%)	850(83.2%)	
Side of the stone	**Left**	26(50.9)	556(54.4)	0.564*
	Right	25 (49.1)	453(44.3)	
	Bilateral	0(0.0)	13(1.3)	
Diameter of the stone	**>10 mm**	32(62.8%)	66(6.5)	0.000#
	1-10 mm	19(37.2%)	956 (93.5)	
Stone location in the ureter	**Upper**	27 (52.9)	353(34.5)	0.000*
	Mid	16(31.4)	192(18.8)	
	Lower	8 (15.7)	477(46.7)	
Number of stones	**Multiple**	16 (31.4)	65(6.4)	**0.000***
	Solitary	35(68.6)	957(93.6)	
Size of ureteroscope	9.5Fr ureteroscope	47(92)	800(78.3)	0.017*
	7Fr ureteroscope	4(8)	222(21.7)	

*The chi-square test has been used
Fisher's Exact test has been used

complications were documented in male than female patients (21.5% vs. 13.4%, respectively) (p= 0.005)[23]. Concerning complications regarding the side of the ureteric stones among the patients of the present study, whether left, right, or bilateral, there was no statistically significant difference. Same findings were noticed in the Okçelik *et al. and* the Kaygısız et al. study, where no statistical significance was detected between patients regarding the stone side[13,32].

The larger stone size (more than 10 mm) in the present study was found to be significantly associated with more complications, which corresponds to that found by Brito *et al.*[33], who found that the rate of complications became higher as the stone size increased. Moreover, Bayar *et al.* study[21] also reported that ureteric stones of 10 mm were associated with more complications. Meanwhile, Rauf *et al.*[34] reported that the stone size was not related to the rate of complications.

Larger ureteric stones were mostly found as proximal ureteric stones among patients in the current study, and overall were associated with more ureteric reaction, and therefore they were more associated with complications. The Esposito *et al.* study[18] showed that lower third ureteric calculi were found in 77 patients (51.7%), mid third ureter stones in 23 patients (15.4%), and upper third ureteric stones in 49 patients (32.9%). Stones in the upper third of the ureter had larger diameters (median diameter: 10.70 mm), while lower third ureteric stones had smaller diameters (median 8.24 mm), and concluded that the use of the Ho: YAG laser lithtripsy is an efficient modality of stone fragmentation, whatever its location[7]. In Adanur *et al.'s* study [35], 7 (21.8%) stones were found in the upper third, 9 (28.2%) stones were found in the mid third, and 16 (50%) stones were found in the lower third of the ureter. Moreover, Öğreden *et al.*[23] reported that overall complication grades became higher as the stones were more proximal ($P < 0.05$). Additionally, Guner *et al.*[36] and Çitamak *et al.*[37] concluded that the proximal stone localisation was among the commonest factors affecting the results of the procedure and complications, reflecting its impact on the time of surgery and success rate. Therefore, calculi diameters and location are significant predictive factors for complications.

CONCLUSIONS

The significant predictive factors for complications were the presence of ureteric abnormalities, stone diameter of more than 10 mm, especially if impacted and associated with mucosal inflammation, the presence of multiple stones, proximal ureteric calculi, and the use of larger-sized ureteroscopes.

The stone side and patient gender do not affect the outcome of the procedure.

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