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Efficacy and Safety of Holmium Laser Lithotripsy for Renal Calculi in Retrograde Intrarenal Surgery: A Comparative Study in Libyan Patients

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Abstract

Background Kidney stones are a common problem that can be treated by different surgical methods. The choice of treatment depends on the stone and patient characteristics and the local resources and skills of the urologists.

Aim The aim of this study was to evaluate the outcomes regarding the safety and effectiveness of retrograde intrarenal surgery (RIRS) using holmium laser lithotripsy for kidney stones sizes of less than or equal to 20, and more than 20 mm.

Methods The study was conducted on 54 patients with renal calculi at a single center using RIRS and holmium lithotripsy from April 2022 to April 2023. Stone size was calculated by summing up the diameters of all renal calculi, and stone-free rate (SFR) was defined as no stone or stone fragment less than 1 mm in the kidney. Results are described as mean ± standard deviation, frequency, and percentages. Chi-squared or unpaired *t*-tests are used for comparison between different groups as appropriate. A *p*-value less than 0.05 is considered significant.

Results The mean intrarenal stone size was 17.8 ± 7.6 mm, with a significant difference in stone size less than or equal to 20 mm and stone size more than 20 mm (19 ± 4.7 and 35 ± 4 mm, respectively). The main operation time was 66 ± 36.5 minutes, with significantly longer operation time for patients with kidney stones more than 20 mm (94.9 ± 34.5 vs. 49 ± 26 for stone size ≤20 mm). There was no difference in the length of stay after operation between the two different stone sizes. The overall immediate SFR was 64.4%, where stone size less than or equal to 20 mm showed a significantly higher SFR (83%) than SFR for stone size more than 20 mm (31%). This SFR increased to 91.1% 1 month later, with 100% clearance for stones size less than or equal to 20 mm compared with only 68% for stones size more than 20 mm. The overall complication rate was 9.2%, most of them were due to urinary tract infections (5 cases) that required intravenous antibiotics. Stone size had no significant effect on the complication rate. There was no significant difference in SFR between lower calyceal stone and other sites of stone.

Keywords
- renal stone
- RIRS
- laser lithotripsy
- safety and effectiveness
- Misurata
- Libya

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Conclusion RIRS combined with holmium laser lithotripsy is a valuable treatment option for patients with renal stones particularly for patients with stones size of less than or equal to 20 mm with a relatively low rate and severity of complications.

ملخص المقال باللغة العربية

مدى أمان تفتيت حصوات الكلى بليزر الهولميوم باستخدام الجراحة الارتجاعية داخل الكلى: دراسة مقارنة للمرضى الليبيين

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الخلفية: تعتبر حصوات الكلى مشكلة شائعة يمكن علاجها بطرق جراحية مختلفة. يعتمد اختيار العلاج على خصائص الحصوات والمريض والموارد والمهارات المحلية لأطباء المسالك البولية.

الهدف: هذه الدراسة تهدف الي تقييم النتائج المتعلقة بسلامة وفعالية الجراحة داخل الكلى الرجعية باستخدام تفتيت الحصوات بليزر الهولميوم لأحجام حصوات الكلى الأصغر من 20 ملم وأكبر من 20 ملم.

الطرق: أجريت الدراسة في مركز واحد على أربعة وخمسين مريضًا يعانون من حصوات الكلى باستخدام الجراحة الارتجاعية داخل الكلى وتفتيت الحصوات بليزر الهولميوم في الفترة من أبريل 2022 إلى أبريل 2023. تم حساب حجم الحصوات من خلال جمع أقطار جميع حصوات الكلى، كما تم تعيين حالة الخلو من الحصوات على أنه لا يوجد حصوة أو شظية حجرية أكبر من مليمترا واحداً في الكلى. تم وصف النتائج بحساب المتوسط والتكرار والنسب المئوية. تم استخدام اختبار مربع كاي أو اختبار (ت) غير المقترن للمقارنة بين المجموعات المختلفة حسب الحالة، وأعتبر أن $P < 0.05$ ذا دلالة إحصائية.

النتائج: كان متوسط حجم الحصوات داخل الكلى 17.8±7.6 ملم، مع وجود اختلاف كبير في حجم الحصوات أقل من 20 ملم وحجم الحصوات أكبر من 20 ملم (19±4.7 و35±4 ملم على التوالي). كان وقت العملية الرئيسي 66 ± 36.5 دقيقة، مع وقت عمليات أطول للمرضى الذين يعانون من حصوات الكلى أكبر من 20 مم (94.9 ± 34.5 دقيقة مقابل 49 ± 26 لحجم الحصوة أقل من 20 مم). لم يكن هناك اختلاف في مدة بقاء المريض في المستشفى بعد العملية بين حجمي الحصوات المختلفتين. كان إجمالي معدل حالة الخلو من الحصوات المباشر 64.4%، حيث أظهر حجم الحصوات أقل 20 مم معدل حالة خلو أعلى بكثير (83%) من حالة الخلو لحجم الحصوات الأكبر من 20 مم (31%). ارتفع معدل حالة الخلو من الحصوات هذه إلى 91.1% بعد شهر واحد، مع حالة خلو وصلت 100% للحصوات التي يقل حجمها عن 20 مم مقارنة بـ 68% فقط للحصي التي يزيد حجمها عن 20 مم. وبلغت نسبة المضاعفات الإجمالية 9.2%، وكان معظمها يسبب التهابات المسالك البولية (5 حالات) التي تتطلب المضادات الحيوية عن طريق الوريد. لم يكن لحجم الحصي أي تأثير كبير على معدل المضاعفات.

الاستنتاج: إن الجراحة داخل الكلى الرجعية مع تفتيت الحصوات بليزر الهولميوم هو خيار علاجي قيم للمرضى الذين يعانون من حصوات الكلى وخاصة للمرضى الذين لديهم حصيات بحجم 20 ملم مع معدل وشدة منخفضة للمضاعفات.

الكلمات المفتاحية: حصوات الكلى، الجراحة داخل الكلى الرجعية، تفتيت الحصوات بالليزر، السلامة والفعالية، مصراتة، ليبيا.

Introduction

Kidney stone disease is a condition that affects more and more people worldwide in recent years.[1] The European prevalence of nephrolithiasis was between 1.2 and 1.4% in 2021.[2] Many advances have been made in the field of urolithiasis, especially in terms of treatment options. The main methods for removing kidney stones are percutaneous nephrolithotomy (PCNL), shock wave lithotripsy (SWL), and retrograde intrarenal surgery (RIRS). The European Association of Urology (EAU) guidelines on urolithiasis (2021) were not conclusive and suggest that (SWL) still represents a viable therapeutic option for kidney stones especially for stones that are smaller than 20 mm, while PCNL is recommended for kidney stones larger than 20 mm located in the renal pelvis or the upper or middle calyces.[2,3] For kidney stones larger than 10 mm in the lower pole, either PCNL or RIRS are advised, as SWL has low efficacy for these stones.[3] However, it is not suitable for patients with morbid obesity, pregnancy, or bleeding disorders.

Flexible ureterorenoscopy (FURS) has evolved from a diagnostic to a therapeutic tool since Marshall first reported seeing a ureteral stone with a nine-French flexible ureteroscope in 1964. The continuous improvement of the instruments has increased the use of FURS for kidney stone removal.[4] Although FURS is not the standard first-line treatment for renal stones larger than 20 mm according to the EAU guidelines on urolithiasis, some researchers have reported favorable outcomes and low complications with the FURS approach and have advocated for its use.[5,6]

Aim

The aim of this study was to evaluate the outcomes regarding the safety and effectiveness of RIRS using Holmium laser lithotripsy for kidney stones sizes of less than or equal to 20, and more than 20 mm.

Methods

This is a retrospective analysis of 54 patients (40 males and 14 females) who underwent RIRS using FURS 9.5fr from Innovax and holmium laser lithotripsy 40 W from POTENT at Aljazeera International Hospital (AIH) in Misurata, Libya, between April 2022 and April 2023. We collected and reviewed the data of the patients who had intrarenal stones and evaluated their preoperative, intraoperative, and postoperative outcomes. We measured the stone size by

calculating the cumulative stone diameter of all intrarenal stones based on computed tomography kidney, ureter, and bladder (CT KUB) scans. We also assessed the intrarenal stone location, stone density, operative time, stone-free rate (SFR), and complications (including urinary tract infection, ureteric injury, intraoperative bleeding, and postoperative steinstrasse).

Surgical Technique

All patients received general anesthesia by one anesthetist with a prophylactic intravenous antibiotic. The patient placed in a lithotomy position and one surgeon performed all the surgeries using a semirigid ureteroscope of 8 to 9.8 Fr from Richard Wolf GmbH in Knittlingen, Germany. It was used to examine the ureter in case it was not Pre-Stented to check the width of the ureter, to dilate it actively, and to insert a hydrophilic guide wire from Cook Medical in Bloomington, Indiana, United States into the renal pelvis. A hydrophilic-coated ureteral access sheath 10 to 12 Fr from Rocamed, French was inserted along the guide wire under fluoroscopic guidance to facilitate stone removal and to reduce intrarenal pressure. A flexible ureteroscope of 9.5 Fr from INNOVAX, China, was also used to access the intrarenal system. A POTENT laser 40 Watts with 272-µm holmium laser fiber was used to fragment the renal stones. The laser settings were adjusted according to the stone size and density, and the usual starting setting was a frequency of 10 Hz and 1 J energy.

The patients underwent a KUB radiography 5 to 8 days after surgery to evaluate their initial stone-free status. If any stone or fragment more than 1 mm remained in the kidney, the patients were advised to exercise more and drink 23 L of fluid daily, with α-receptor blockers. They underwent a second image by CT KUB 30 days after surgery to assess the final SFR. If the SFR was still poor, additional procedures or treatments were offered to clear the stones. The double J stent was also removed to ease stone extraction if fixed after surgery. We defined stone-free status as no stone or fragment less than 1 mm in the kidney.

Statistical Analysis

The data was presented as frequencies (percentages) or as means ± standard deviation of the mean. Chi-squared test was used to compare the SFR among patients for different stone sizes (≤20mm and > 20 mm) and places. An unpaired Student's *t*-test is used to compare the difference between two groups' means.

Ethical Approval

The ethical approval for the study was received from the ethical committee of AIH, and verbal consent was taken from patients.

Results

This study included 54 patients (40 men and 14 women) with a mean age of 48.5 ± 24 years (►**Table 1**). The mean intrarenal stone size was 17.8 ± 7.6 mm, with a significant difference in stone size less than or equal to 20 mm and stone size more than 20mm (19 ± 4.7 and 35 ± 4 mm, respectively).

The main operation time was 66 ± 36.5 minutes, with significantly longer operation time for patients with kidney stones more than 20 mm (94.9 ± 34.5 vs. 49 ± 26 for stone size ≤20 mm). There was no difference in the length of stay after operation between the two different stone sizes (1.3 ± 0.9 days for stone size ≤20 mm vs. 1.0 ± 0.25 for stone size >20 mm; ►**Table 1**).

The overall immediate SFR was 64.4%, where stone size less than or equal to 20 mm showed a significantly higher SFR (83%) than SFR for stone size more than 20 mm (31%). This SFR increased to 90,7% as a total 1 month later, with 100% clearance for stones size less than or equal to 20 mm compared with only 68% for stones size more than 20 mm. 26 and 28 patients have right side and left side renal stone, respectively (►**Table 1**).

The overall complication rate was 9.2%, most of them were due to urinary tract infection (5 cases) that required intravenous antibiotics, no recorded case of ureteric injury, one case of Intra-Renal bleeding managed conservatively, and one case of post-operative steinstrasse who has a double J stent managed by semirigid uretrorenoscope and stone removal. Stone size had no significant effect on the complication rate (►**Table 1**).

►**Table 2** shows that the location of the stone did not have a significant effect on immediate SFR, with the highest SFR of 100% found in stones located in the middle calyceal, followed by upper calyceal (66.6%), pelvis (62.5%), and lower calyceal (50%). After 1 month of follow-up, SFR values increased to 100% for upper calyceal stones, 79.2% for pelvis stones, and 100% for lower calyceal stones. However, there was no significant difference in immediate SFR between lower intrarenal stones and other locations in the kidney (p-value > 0.05 using the chi-squared test).

Discussion

Many procedures are used for the removal of kidney stones; each has its advantages and disadvantages. PCNL is an excellent minimal-invasive approach for big renal stones.[7] However, it has some disadvantages such as being an aggressive surgery that approaches the kidney through renal parenchyma. The prone position that is routinely used for this procedure may increase the anesthetic risk and decrease the oxygen saturation, especially in obese and elder patients with respiratory disorders.[8] Major complications seen during and after this operation include major vessel injury, hemorrhage, hydrothorax, septicemia, bowel injury, and renal collecting system perforation. An interest in other treatment modalities increased due to these potential complications.[9,10] On the other hand, extracorporeal shock wave lithotripsy (ESWL) was the most widely used treatment for urolithiasis,[11] and a preferred treatment option because it can successfully treat renal stones in 74 to 88% of cases, with many advantages, such as no need for anesthesia, and quick recovery.[12] However, we have to consider that ESWL also has some disadvantages and risks, mainly renal damage at a rate of 2.5%.[13] Moreover, the SFR falls down

Table 1 A comparison between kidney stone sizes of less than or equal to 20, and more than 20 mm

Number of patients	Total—54	Male—40	Female—14	Test of significance[a]
Mean age (years ± SD)	48.5 ± 24			
Mean stone size ± SD (number)	Mean 17.8 ± 7.6 (54)	≤20 mm 19 ± 4.7 (35)	>20 mm 35 ± 4 (19)	<0.001[b]
Operative time minutes (mean ± SD) (numbers)	Mean 66 ± 36.5 (54)	≤20 mm 49 ± 26 (35)	>20 mm 94.9 ± 34.5 (19)	<0.001[b]
Length of stay days (mean ± SD) (number)	Mean 1.2 ± 0.76 (54)	≤20 mm 1.3 ± 0.9 (35)	>20 mm 1.0 ± 0.25 (19)	NS
Immediate percentage stone-free rate (number)	Overall, 64.8% (35)	≤20 mm 83% (29)	>20 mm 31% (6)	<0.01[c]
One month percentage stone-free rate	Overall, 90.7%(48)	≤20 mm 100% (35)	>20 mm 68% (13)	<0.01[c]
Percentage complications rate	Overall, 9.2% (5)	≤20 mm 8.5% (3)	>20 mm 10.5% (2)	NS[c]
Urinary tract infection	Overall, 9.2% (5)	≤20 mm 8.5% (3)	>20 mm 10.5% (2)	NS[c]
Intraoperative bleeding	Overall, 1.9% (1)	≤20 mm 3% (1)	>20 mm 0% (0)	NS[c]
Postoperative steinstrasse	Overall, 1.9% (1)	≤20 mm 0% (0)	>20 mm 5.3% (1)	NS[c]
Percentage laterality (number)	Right 48% (26)		Left 52% (28)	NS[c]

Abbreviations: NS, non-significant; SD, standard deviation.
[a]The significance of differences according to stone size.
[b]Using unpaired Student's *t*-test.
[c]Using the chi-squared test.

Table 2 The effect of stone location on the immediate and 1-month follow-up SFR

Location of the stone, *n*	Immediate SFR, % (*n*)	SFR after 1 month % (*n*)
Lower calyceal stone (12)	50 (6)	100 (12)
Pelvis (24)	62.5 (15)	79.2 (19)
Upper calyceal stone (12)	66.6 (8)	100 (12)
Middle calyceal stone (6)	100 (6)	100 (6)
Total number of patients (54)	64.8 (35)	90.7 (49)

Abbreviation: SFR, stone-free rate.

to 70% in cases of multiple renal stones or lower calyceal stones. Steinstrasse has been reported in 4% to 7% of cases after ESWL, subcapsular hematoma, and pancreatitis have been reported as serious complications of ESWL.[14]

The recent advances in flexible ureteroscopy and holmium laser lithotripsy allow successful access to renal stones through natural orifices and allow for 1-day surgery with an accepted and low complication rate compared with other approaches, making it a choice of great interest for managing all renal stones. Therefore, we decided to compare the outcomes regarding the effectiveness and safety of RIRS using Holmium laser lithotripsy for kidney stone sizes of less than or equal to 20, and more than 20 mm in our clinic.

In terms of operation time, our study found that patients with kidney stones more than 20 mm had a significantly longer operation time compared with those with stones less than 20 mm. Similar results were reported by Breda et al,[10] who found that the operative time for stones 20 mm or larger was approximately 83.3 minutes. This is an expected result since larger stones require more time and effort to break up and remove. Despite the longer operation time for patients with larger stones, there was no significant difference in the length of stay in the hospital after the operation between the two groups. This suggests that the size of the kidney stone does not necessarily impact the recovery time or the need for an extended hospital stay.

The effectiveness of our procedure was evaluated by measuring the immediate SFR and the SFR after 1 month of the operation. The study reported an overall immediate SFR of 64.4%, with kidney stones less than or equal to 20 mm, had a significantly higher SFR of 83%, compared with a lower SFR of 31% for patients with stones more than 20 mm. Within 1 month, the SFR increased to 90,7% overall. Patients with stones less than or equal to 20 mm achieved a 100% stone clearance rate, while patients with stones more than 20 mm had a clearance rate of 68%. These findings suggest that the size of the kidney stone plays a significant role in the immediate SFR and the overall effectiveness of the procedure, where smaller stones are more likely to be completely cleared immediately after the operation and have a higher chance of achieving complete stone clearance within 1 month. Larger stones may require additional interventions or follow-up procedures to achieve optimal stone clearance. Similar results to our findings were reported by several other research groups.[5,10]

The safety of the procedure was assessed by monitoring postoperative complications. Although rare, literature mentions major complications such as intussusception, ureteric avulsion, and iatrogenic trauma.[15] However, no major complications were encountered during our study. All complications were either grade 1 or grade 2 according to the Clavien Dindo classification, accounting for 9.2% of cases. The most common complication was urinary tract infection, which was managed with antibiotics, followed by hematuria. These findings are consistent with the literature, which also reports urinary tract infection as a common complication.[10,15,16]

FURS faces a challenge when dealing with stones in the lower calyces. This is the hardest part of the kidney to reach. A study by Pearle et al,[17] showed that fixable ureteroscopy had low SFRs for lower-pole stones, even when they were smaller than 10 mm. However, our study does not agree with this observation, as we found no statistically significant difference in the SFR between lower calyceal stone location and other renal sites of stone, regardless of the stone size. This may be due to the improvement in new flexible ureteroscopes, which can reach the lower-pole calyces in 93% of cases.[18]

Conclusion

RIRS combined with holmium laser lithotripsy is a valuable treatment option for patients with renal stones. Our study demonstrated a satisfactory SFR, particularly for patients with a total stone size of less than or equal to 20 mm. Additionally, we observed a relatively low rate and severity of complications. Furthermore, there is growing interest in utilizing this technique for treating larger stones, further highlighting the potential benefits and versatility of RIRS with holmium laser lithotripsy as a treatment modality for renal stones.

Limitations of the Study

As this was a single-center study with a limited number of patients, generalizing the findings to a larger population may be challenging. Therefore, a multicenter study with a larger sample size is necessary to confirm and validate the results.

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None.

Conflicts of Interest
None declared.

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