OUTCOMES OF URETERORENOSCOPY WITH PNEUMATIC LITHOCLAST FOR URETERIC STONE MANAGEMENT AT A REGIONAL CENTER: A RETROSPECTIVE STUDY

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Abstract: The management of ureteric stones has significantly evolved with the advancement of minimally invasive techniques. Ureterorenoscopy (URS) with pneumatic lithoclast has become favored due to its efficacy and safety, providing high success rates across various stone locations. Objective: To share our experiences and outcomes of treating ureteric stones using ureterorenoscopy and pneumatic lithoclast at our regional center. Methods: From 2014 to 2022, 220 patients with ureteral calculi underwent 221 URS procedures using a pneumatic lithoclast. Preoperative evaluation included plain radiography, ultrasound scan, intravenous urography, and CT KUB. Postoperative assessments with plain film radiography and, if necessary, ultrasound or CT KUB were conducted immediately or a few days after the procedure. Results: The overall stone-free rate achieved was 95.4%. Specific success rates based on stone location were 88.4% for upper, 97% for middle, and 100% for lower ureteral stones. The primary cause of treatment failure, occurring in 4.5% of cases, was stone migration. Conclusion: Ureteroscopic intra-corporeal lithotripsy is a reliable and safe treatment modality for ureteric stones of various sizes and locations, demonstrating high efficacy when performed by experienced practitioners.

Keywords: Intra-corporeal lithotripsy, Pneumatic lithoclast, Stone migration, Ureteric stones, Ureterorenoscopy, Urology, Stone-free rate

Introduction

Over the past two decades, the landscape of urinary stone treatment has undergone significant transformations in various regions, including ours. Historically, extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy, and laparoscopic ureterolithotomy have been prominent among the endourological treatment options for managing urinary stones. (1, 2). However, due to the absence of advanced lithotripsy machines in our facilities, ESWL often fails short of effectively addressing a substantial fraction of ureteral calculi cases, necessitating more invasive approaches. (3, 4).

Ureterorenoscopy with intra-corporeal lithotripsy (URS-ICL) has emerged as a preferred intervention in cases where ESWL is unsuccessful (5). Indications for URS-ICL include failed ESWL treatments, steinstrasse conditions post-ESWL, larger stone sizes, radiolucent stones, and, specifically, lower ureteral stones. Our clinical preference leans towards URS as the primary treatment modality following unsuccessful medical management, particularly for most lower and middle ureteric stones, where the efficacy of ESWL has been notably poor (6, 7).

Recent advancements have seen the introduction of smaller-calibre semirigid ureteroscopes (4.5 and 6 Fr) alongside more effective intracorporeal lithotriptors such as the lithoclast and holmium laser (8). These innovations have significantly enhanced the success rates and reduced the morbidity associated with these procedures. In this context, our experience with using an 8.5 Fr semirigid ureteroscope alongside a lithoclast has shown promising results in the management of ureteral calculi (3, 9).

The objective of this report is to rationalize the use of semirigid ureterorenoscopy in our clinical setting, presenting outcomes that underscore its efficacy and safety, thereby supporting its role as a fundamental treatment modality for ureteral calculi where non-invasive options are limited or ineffective (10, 11).

Methodology

Between January 2014 and October 2022, a total of 220 patients suffering from ureteral calculi underwent ureterorenoscopy with intra-corporeal lithotripsy (URS-ICL) at Kutyana Memon Hospital, Karachi, Pakistan. This hospital is recognized as the largest regional centre in the area, providing services comparable to those of a tertiary care centre (12). The procedures were exclusively conducted by a single urologist. The patient cohort included 190 men and 30 women, yielding a gender ratio of 6.3:1. The average age of the patients was 34.45 years, ranging from 20 to 53 years. Of the cases reviewed, 208 involved unilateral stones, while 12 cases involved bilateral stones, totalling 221 treatment sessions. Notably, one patient required a repeat URS due to postoperative haematuria (13, 14).

Before undergoing URS-ICL, each patient was subjected to a comprehensive pre-operative assessment that included a detailed history, physical examination, routine biochemical
analyses, complete blood count, urinalysis, and urine cultures. Any pre-existing urinary tract infections were treated before surgery. Additionally, prophylactic antibiotics were administered intravenously one hour before the procedure. Diagnostic imaging, including a plain abdominal film of the kidneys, ureter, and bladder (KUB), intravenous urography or CT KUB, and sonography, was performed preoperatively. Postoperative imaging consisted of an immediate X-ray KUB and follow-up sonography two weeks after the procedure to assess for stone-free status or the presence of asymptomatic residual fragments smaller than 3 mm in diameter (15, 16).

During the procedure, conducted under spinal anaesthesia, patients were positioned in a semi-lithotomy stance. A semirigid ureteroscope, sized 8-9 6-Fr (Olympus/Richard Wolf, Germany), equipped with a pneumatic lithotriptor (Swiss Lithoclast Master, Germany), was introduced into the ureter. The ureteroscope was navigated over a securely placed guidewire, which was introduced through the ureteroscope after identifying the ureteric orifice. This technique, referred to as the non-dilating ureteric orifice technique, ensured minimal trauma and facilitated the introduction of the scope. Stone disintegration was primarily achieved using two lithoclast probes (0.8 mm and 1 mm). Most fragmented stones were left in situ for spontaneous passage, but larger fragments were extracted using stone forceps (17, 18).

Post-procedure management involved placing a ureteral catheter (4 or 5 Fr) or a double-J stent (4.7 or 6 Fr) if there were indications such as ureteral oedema, ureteral injury, impaired renal function, significant stone burden, or upward migration of stone fragments. The ureteral catheter was typically removed after 24 hours, and the double-J stent was removed two weeks postoperatively. In cases where stone fragments migrated upward, additional ESWL was administered postoperatively (4, 19).

This structured approach ensured high standards of care and patient safety, while the advanced imaging and surgical techniques contributed to effective treatment outcomes.

**Results**

In the retrospective analysis of ureterorenoscopy with extracorporeal shock wave lithotripsy (URS-ICL) performed on 220 patients at Kutoryan Memon Hospital, Karachi, Pakistan, the success rates varied according to the location of the ureteral stones. Specifically, success rates for single-session URS-ICL targeting upper, middle, and lower ureteral stones were 88.4%, 97.0%, and 100.0% respectively. For the seven patients with unilateral multiple stone locations, including cases with Steinstrasse, the success rate was 71.4%. Consequently, the overall success rate after a single session of URS-ICL was 94.5%, equating to 208 successful treatments out of 220 attempts. These results are detailed in Table 2.

Stone migration into the kidney was the primary cause of treatment failure, occurring in 8 patients with upper ureteral stones and one patient each with stones in the middle and lower ureter. Among the 10 patients (4.5%) who experienced upward stone migration, 8 underwent a single additional session of extracorporeal shock wave lithotripsy (ESWL), while two required two sessions. Additionally, one patient required a repeat URS due to complications of haematuria. Despite these challenges, the overall stone clearance rate eventually reached 100%, with all 220 patients achieving stone-free status.

The placement of double-J stents was necessary in 14.5% of cases (32 out of 220), reflecting the protocol for managing conditions such as ureteral oedema or significant stone burden. Complications were relatively minimal but included postoperative fever in 2.2% of patients (5 cases), which resolved with supportive treatments. One patient experienced haematuria and clot retention necessitating another procedure to remove an impacted fragment and subsequent Foley catheterization with normal saline irrigation. False passaging at the site of impacted stones occurred in two patients, necessitating double-J stent placement. Fortunately, there were no major complications such as ureteral avulsion. The details of these complications are summarized in Table 3.

<table>
<thead>
<tr>
<th>Stone location (n)</th>
<th>Multiple and Steinstrasse (n=7)</th>
<th>Total (n=220)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper ureter (n=48)</td>
<td>07</td>
<td>12</td>
</tr>
<tr>
<td>Middle ureter (n=25)</td>
<td>05</td>
<td>32</td>
</tr>
<tr>
<td>Lower ureter (n=140)</td>
<td>01</td>
<td>4</td>
</tr>
<tr>
<td>Overall success rate (n=220)</td>
<td>208 (94.5%)</td>
<td></td>
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</tbody>
</table>

**Table 1: Patient characteristics and stone location:**

<table>
<thead>
<tr>
<th>Stone location (n)</th>
<th>Multiple and Steinstrasse (n=7)</th>
<th>Total (n=220)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed ESWL (no)</td>
<td>07</td>
<td>12</td>
</tr>
<tr>
<td>Double-J stent (no)</td>
<td>05</td>
<td>32</td>
</tr>
<tr>
<td>Hospital stay (d)</td>
<td>01</td>
<td>4</td>
</tr>
<tr>
<td>Day case surgery (no)</td>
<td>03</td>
<td>03</td>
</tr>
</tbody>
</table>

ESWL = Extracorporeal shock wave lithotripsy.

<table>
<thead>
<tr>
<th>Stone location (n)</th>
<th>Success, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper ureter (n=48)</td>
<td>40 (83.3%)</td>
</tr>
<tr>
<td>Middle ureter (n=25)</td>
<td>24 (96.0%)</td>
</tr>
<tr>
<td>Lower ureter (n=140)</td>
<td>139 (99.69%)</td>
</tr>
<tr>
<td>Multiple and Steinstrasse (n=7)</td>
<td>5 (71.4%)</td>
</tr>
<tr>
<td>Overall success rate (n=220)</td>
<td>208 (94.5%)</td>
</tr>
</tbody>
</table>

**Table 2. Success rates according to stone location.**

<table>
<thead>
<tr>
<th>Stone location (n)</th>
<th>Adverse event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper ureter (n=48)</td>
<td>Postoperative fever (&gt; 38.5 °C)</td>
</tr>
<tr>
<td>Middle ureter (n=25)</td>
<td>Hematuria with blood clot retention</td>
</tr>
<tr>
<td>Lower ureter (n=140)</td>
<td>Total</td>
</tr>
<tr>
<td>Multiple and Steinstrasse (n=7)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Adverse event</th>
<th>Patients, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative fever (&gt; 38.5 °C)</td>
<td>5 (2.2%)</td>
</tr>
<tr>
<td>Hematuria with blood clot retention</td>
<td>1 (0.45%)</td>
</tr>
<tr>
<td>Total</td>
<td>6 (2.72%)</td>
</tr>
</tbody>
</table>

Discussion

The minimally invasive management of ureteral calculi, notably through extracorporeal shock wave lithotripsy (ESWL) and ureteroscopy (URS), has evolved significantly, guided by factors such as stone size, location, composition, and the technology employed. ESWL acknowledged for its non-invasive and anaesthesia-free approach, is nonetheless limited by its dependency on multiple sessions and auxiliary procedures to achieve satisfactory outcomes, often accompanied by discomfort due to colic and other urinary symptoms. Conversely, URS, particularly with semirigid modalities, tends to yield higher stone-free rates, albeit with potentially higher direct costs as noted by Huang and colleagues in a cost-effectiveness study comparing URS and ESWL in a Taipei City hospital (20, 21).

Reflecting on the guidelines from the American Urological Association and the European Association of Urology, both ESWL and URS are considered viable first-line treatments for nonpregnant adults with unilateral ureteral stones, provided there is normal contralateral renal function. Notably, the meta-analysis of 244 studies identified URS as more effective for stones larger than 1 cm across all ureteral segments, except for proximal ureteral stones smaller than 1 cm where ESWL might be slightly superior (6, 22). The current study underscores the high efficacy of URS-ICL, demonstrating a 94.5% overall clearance rate. The stratification by stone location revealed that lower ureteral stones had the highest clearance rate at 99.69%, followed by middle and upper ureteral stones at 96% and 83.3%, respectively. The only significant limitation to success was upward stone migration, occurring in 4.54% of cases. The incorporation of the holmium laser in other settings has been shown to enhance the efficacy of URS by reducing stone retropulsion, a problem less prevalent in our approach which utilizes pneumatic lithotripters (7, 23).

Our institution’s strategy to mitigate stone retropulsion includes several procedural modifications such as the reverse Trendelenburg position with lateral rotation, reduced irrigant pressure, and the peripheral targeting of stones. Despite the availability of devices like the Stone Cone and NTrap to prevent retrograde stone migration, our experience with such tools is limited due to their unavailability and the reported complications in extracting disintegrated stone fragments from these devices (9, 10). Stenting remains a critical component of post-URS management to alleviate symptoms of obstruction, facilitate stone passage, and prevent complications like strictures. In our series, stents were used in 14.5% of cases, mainly driven by complications such as upward stone migration or suspected ureteral injury. The decision to stent is predominantly determined intraoperatively based on surgical outcomes and specific patient conditions (11, 24).

The evolution of ureteroscopy has proven to be a highly effective, safe, and feasible approach for treating ureteric stones, achieving high success rates and low complication rates in our study, consistent with existing literature. This indicates that our accumulated experience has honed our skills in managing ureteral calculi effectively using this technique. As technological advancements continue, flexible ureteroscopy is poised to become increasingly vital in both diagnosing and treating upper urinary tract diseases at our centre, enhancing our capability to provide cutting-edge care to our patients.

Conclusion

Ureteroscopy has proven to be a highly effective, safe, and feasible approach for treating ureteric stones, achieving high success rates and low complication rates in our study, consistent with existing literature. This indicates that our accumulated experience has honed our skills in managing ureteral calculi effectively using this technique. As technological advancements continue, flexible ureteroscopy is poised to become increasingly vital in both diagnosing and treating upper urinary tract diseases at our centre, enhancing our capability to provide cutting-edge care to our patients.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate.
Approved by the department concerned. (IRB-LIMS-2013-021)

Consent for publication
Approved

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Not applicable

Conflict of interest

The authors declared an absence of conflict of interest.

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Final Approval of version

GHULAM MUSTAFA PATHAN (Assistant Professor and Consultant)
Drafting

SANTOSH KUMAR (MBBS FCPS) & MUHAMMAD ALI YOUSUF
Concept & Design of Study

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