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EFFICACY OF SEMIRIGID URETEROSCOPE WITH PNEUMATIC LITHOTRIPSY IN MANAGEMENT OF URETERIC CALCULUS

Original Research

Siraj ul Islam[1]*, Asif[1]
[1]Department of Urology, Lady Reading Hospital, Peshawar, Pakistan.
Corresponding Author: Siraj ul Islam, Department of Urology, Lady Reading Hospital, Peshawar, Pakistan, sirajulislam65@hotmail.com
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ABSTRACT

Background: Ureteric calculi are a common clinical concern and present a therapeutic challenge, particularly in resource-limited settings. While various global studies have documented the efficacy of pneumatic lithotripsy, there is a noticeable gap in regional data from Khyber Pakhtunkhwa, Pakistan. Given the province's socioeconomic constraints and limited access to advanced technology, semi-rigid ureteroscopy with pneumatic lithotripsy offers a cost-effective and minimally invasive treatment alternative. This study was conducted to assess its efficacy in the local population.

Objective: To determine the stone-free rate of pneumatic lithotripsy in adults diagnosed with ureteric calculi.

Methods: This descriptive study was conducted at the Department of Urology, Lady Reading Hospital, Peshawar, from January 16 to July 15, 2021. A total of 109 adult patients aged 18 to 60 years with ureteric stones confirmed on ultrasonography were enrolled using non-probability consecutive sampling. Patients with anatomical abnormalities, prior interventions in the same ureter, chronic kidney disease, or contraindications to the procedure were excluded. All patients underwent semi-rigid ureteroscopy using a Karl Storz 6.4×8.0 Fr ureteroscope under general anesthesia, with stone fragmentation performed via Swiss LithoClast pneumatic lithotripsy. Postoperative follow-up at 4 weeks included KUB ultrasound to confirm stone clearance, defined as complete absence of echogenic foci or residual fragments ≤4 mm. Data were analyzed using SPSS version 26.

Results: The mean age was 41.28 ± 10.33 years, mean stone size 33.55 ± 5.33 mm, and mean BMI 24.02 ± 2.66 kg/m². Of 109 participants, 70 (64.2%) were male and 58 (53.2%) were aged above 40 years. Stones >30 mm were observed in 66 patients (60.6%). The overall stone-free rate achieved was 85.3% (n=93).

Conclusion: Semi-rigid ureteroscopy with pneumatic lithotripsy is a safe, effective, and economically feasible option for managing ureteric stones in adults, especially in settings with limited healthcare resources.

Keywords: Body Mass Index, Lithotripsy, Minimally Invasive Surgical Procedures, Pneumatic Devices, Stone-Free Rate, Ureteroscopy, Ureteral Calculi

INTRODUCTION

Ureterolithiasis, the presence of stones within the ureter, is a frequently encountered urological condition with an estimated annual incidence of 1 in 1000 individuals, making it a relatively common cause of acute flank pain in adults. Its rising global prevalence has been linked to a multitude of factors, including dehydration, dietary patterns rich in oxalates, calcium, and purines, as well as genetic disorders such as hyperoxaluria and cystinuria (1). Additionally, certain medical conditions—including urinary tract infections, renal tubular acidosis, and hyperparathyroidism—have been identified as contributors to stone formation. Lifestyle elements, particularly sedentary behavior, obesity, and the use of specific medications, further increase susceptibility to ureteric calculi (2,3). Conditions causing urinary stasis, such as neurogenic bladder or anatomical abnormalities, can also promote the development of ureteral stones. Clinically, ureterolithiasis presents with a range of symptoms including acute colicky flank pain, hematuria, and signs of urinary tract infection such as dysuria, urinary frequency, urgency, and fever. Epidemiological data reveal variations in prevalence across different age groups, sexes, and ethnicities, with men being affected approximately twice as often as women (4,5). The growing burden of ureteric stones necessitates effective and accessible treatment modalities, particularly in low-resource settings.

Among the available endoscopic options, ureteroscopy coupled with lithotripsy remains the cornerstone of minimally invasive stone management. Several lithotripsy techniques are employed, including electrohydraulic, ultrasonic, laser, and pneumatic modalities. The pneumatic lithotripter stands out due to its durability, cost-effectiveness, and reusability, making it a preferred option in many developing regions (6-8). Operating through the transmission of air pressure via a metallic probe, pneumatic lithotripsy offers a practical and straightforward approach to stone fragmentation (9,10). Although laser lithotripsy has emerged as a technologically advanced alternative, its high acquisition and maintenance costs, limited availability in resource-constrained areas, and technical fragility limit its widespread use, particularly in economically challenged provinces like Khyber Pakhtunkhwa (11). Despite the increasing global interest in cost-effective urolithiasis management, there remains a lack of region-specific data from Khyber Pakhtunkhwa, Pakistan—a province marked by socio-political instability and financial constraints. In such a setting, the accessibility and affordability of pneumatic lithotripsy make it a viable first-line therapeutic option. Therefore, this study was designed to evaluate the stone-free rate following pneumatic lithotripsy in adult patients presenting with ureteric calculi, aiming to generate local evidence on its effectiveness and to inform clinical decision-making in similar low-resource healthcare environments

METHODS

This descriptive study was conducted at the Department of Urology, Lady Reading Hospital, Peshawar, over a six-month period from January 16, 2021, to July 15, 2021. The study included adult male and female patients aged between 18 and 60 years who were diagnosed with a proximal ureteric stone measuring more than 10 mm. The diagnosis was confirmed via ultrasonography, demonstrating an echogenic focus with posterior acoustic shadowing in the proximal ureter. Patients were excluded if they had congenital or acquired ureteral or bladder anomalies, a history of prior surgical or endoscopic intervention in the same ureter, chronic kidney disease, or any contraindications to undergoing semi-rigid ureteroscopy or pneumatic lithotripsy. A total of 109 participants were enrolled, with the sample size calculated using the WHO sample size calculator based on an expected stone-free rate of 83.5%, a margin of error of 7%, and a 95% confidence level (8). A non-probability consecutive sampling technique was employed. Ethical approval for the study was obtained from the hospital's Institutional Review Board and the College of Physicians and Surgeons Pakistan (CPSP), and written informed consent was obtained from all participants prior to inclusion in the study.

All procedures were carried out under general anesthesia in the lithotomy position. A semi-rigid ureteroscopy was performed using a Karl Storz ureteroscope (6.4 × 8.0 Fr), with real-time imaging assistance via an image intensifier. Stone fragmentation was achieved using a pneumatic lithotripter (Swiss LithoClast). Standardized post-operative care protocols were followed. Patients were reassessed at four weeks post-procedure using ultrasonography of the kidneys, ureters, and bladder (KUB) to determine the stone-free status. Treatment was considered effective if ultrasound revealed either the absence of echogenic foci or residual fragments smaller than 4 mm. All collected data, including baseline demographics, were entered and analyzed using SPSS version 26. Continuous variables were expressed as means and standard deviations, whereas categorical variables, including the primary outcome of efficacy, were reported as

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frequencies and percentages. To examine the association of potential effect modifiers, the chi-square test was employed, with a significance level set at $p < 0.05$.

RESULTS

The mean age of the study participants was 41.28 ± 10.33 years. The average stone size recorded was 33.55 ± 5.33 mm, and the mean body mass index (BMI) was 24.02 ± 2.66 kg/m². A total of 58 participants (53.2%) were aged over 40 years, while 51 (46.8%) were aged 40 or younger. The majority of patients were male, comprising 70 individuals (64.2%), while females constituted 39 participants (35.8%). BMI values above 24.0 kg/m² were observed in 46 patients (42.2%), and 63 patients (57.8%) had BMI values at or below this threshold. Laterality distribution showed that 74 patients (67.9%) had left-sided ureteric calculi, whereas 35 (32.1%) had stones on the right side. Regarding socioeconomic and demographic indicators, 34 patients (31.2%) were employed, and 75 (68.8%) were unemployed. Urban residents made up the majority, accounting for 65 individuals (59.6%), while 44 (40.4%) were from rural areas. Educational status revealed that 60 participants (55.0%) had education up to matric level or below, whereas 49 (45.0%) had higher education. Comorbid medical conditions were identified in 24 participants (22.0%). Notably, 66 patients (60.6%) had stone sizes exceeding 30 mm, and the remaining 43 patients (39.4%) had stones measuring 30 mm or less. The primary outcome of the study—efficacy of semi-rigid ureteroscopy combined with pneumatic lithotripsy—was achieved in 93 patients, representing a stone clearance rate of 85.3%. Sixteen patients (14.7%) had residual stones, indicating failure of complete stone fragmentation and clearance.

Subgroup analysis revealed notable variations in the efficacy of semi-rigid ureteroscopy with pneumatic lithotripsy across demographic and clinical parameters. Patients aged 40 years or younger achieved a slightly higher stone clearance rate (86.3%) compared to those older than 40 years (84.5%). Males demonstrated a considerably higher efficacy rate (91.4%) than females (74.4%), suggesting potential gender-based differences in anatomical or physiological response to the procedure. Regarding BMI, patients with a BMI of 24 or below had a clearance rate of 85.7%, while those with higher BMI showed a slightly lower success rate (84.8%). Left-sided stones responded slightly better to treatment (85.1%) than right-sided stones (85.7%). Most notably, patients with stones measuring 30 mm or less achieved a significantly higher efficacy (95.3%) compared to those with larger stones (>30 mm), who had a success rate of 78.8%. These findings indicate that gender and stone size may be influential factors in determining the procedural success and warrant further investigation.

Table 1: Descriptive statistics of study participants (n = 109)

Parameters	Mean	Std. Deviation
Age (years)	41.28	10.333
Stone size (mm)	33.55	5.331
BMI (kg/m^2)	24.017	2.6691

Table 2: Clinical and demographic characteristics of study participants (n = 109)

Parameters	Subgroups	Frequency	Percent
Age (years)	40 or below	51	46.8
	More than 40	58	53.2
Gender	Male	70	64.2
	Female	39	35.8
BMI (kg/m^2)	24.0 or below	63	57.8
	more than 24.0	46	42.2
Laterality	Right	35	32.1
	Left	74	67.9
Profession	Employed	34	31.2
	Unemployed	75	68.8
Residence	Rural	44	40.4
	Urban	65	59.6
Education	Matric or below	60	55.0
	Above Matric	49	45.0
Comorbidities	Yes	24	22.0
	No	85	78.0

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Parameters	Subgroups	Frequency	Percent
Stone size (mm)	30 or below	43	39.4
	more than 30	66	60.6

Table 3: Efficacy of Semi rigid ureteroscopy with pneumatic lithotripsy (n = 109)

		Frequency	Percent
Efficacy	Yes	93	85.3
	No	16	14.7
	Total	109	100.0

Table 4: Subgroup Analysis of Efficacy

Subgroup		Total (n)	Stone Free (n)	Efficacy (%)
Age	Age ≤ 40 years	51	44	86.3%
	Age > 40 years	58	49	84.5%
Gender	Male	70	64	91.4%
	Female	39	29	74.4%
BMI	BMI ≤ 24	63	54	85.7%
	BMI > 24	46	39	84.8%
Laterality	Right ureteric stone	35	30	85.7%
	Left ureteric stone	74	63	85.1%
Stone size	Stone size ≤ 30 mm	43	41	95.3%
	Stone size > 30 mm	66	52	78.8%

Figure 1 Distribution of Stone Size

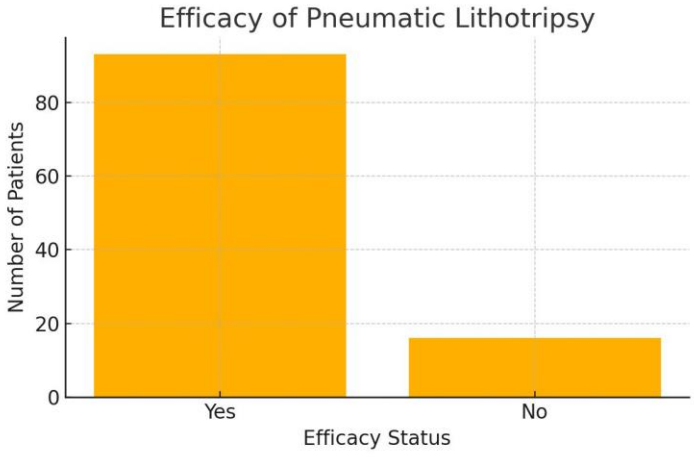

Figure 2 Efficacy of Pneumatic Lithotripsy

DISCUSSION

Stones located in the proximal ureter represent a particularly difficult subset of urinary tract stone disease, especially when large in size. Despite advances in minimally invasive urological techniques, selecting the optimal management strategy remains a subject of ongoing debate due to the variable success rates, complication profiles, and resource limitations in many healthcare settings (12,13). While flexible ureteroscopy (URS) combined with laser lithotripsy has emerged as a preferred approach in developed countries due to its high efficacy and precision, its widespread adoption in low-resource settings remains limited. The procedure requires significant technical expertise, stenting protocols, and expensive, fragile instruments that demand regular maintenance and repair, increasing overall treatment costs (14-16). In contrast, semi-rigid ureteroscopy paired with pneumatic lithotripsy continues to serve as a viable and accessible

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alternative in under-resourced regions. This study reported a stone-free rate (SFR) of 85.3% at four weeks follow-up, aligning with international findings and reinforcing the utility of pneumatic lithotripsy in managing large proximal ureteric calculi. However, ancillary procedures were required in 14.7% of cases, reflecting the challenge of retropulsion and potential access failure, which remains a limitation of semi-rigid URS. Comparatively, a similar success rate was observed in other studies evaluating semi-rigid URS for large ureteric stones, though the rates of auxiliary interventions varied slightly depending on instrumentation and stone location (17,18).

This study's inclusion criteria focused exclusively on large proximal ureteric stones with a mean size of 33.55 ± 5.33 mm, offering a more homogeneous sample compared to other studies that included a broader range of stone locations and sizes. Interestingly, while the overall efficacy was high, subgroup analysis suggested that stone size and patient gender had a notable impact on outcomes, with better clearance rates observed in smaller stones and male patients. These findings highlight the need for individualized treatment planning and suggest that anatomical and physiological factors may influence treatment efficacy. When compared to extracorporeal shockwave lithotripsy (SWL), which is often selected for its non-invasive nature and outpatient feasibility, pneumatic lithotripsy offers more consistent SFRs despite requiring general anesthesia and endoscopic access. SWL has known drawbacks, including multiple treatment sessions, lower stone clearance for larger stones, and high retreatment rates, often resulting in decreased patient compliance (19,20). Other alternatives such as percutaneous nephrolithotomy (PCNL), antegrade URS, and laparoscopic or open ureterolithotomy may offer high stone clearance but involve greater morbidity, longer hospital stays, and increased procedural risks, making them less desirable in primary settings (21).

A significant strength of the current study was its focus on a clearly defined patient population in a resource-limited setting, offering region-specific insights into the practicality of semi-rigid URS with pneumatic lithotripsy. The use of a single surgical team and uniform postoperative protocols added consistency to outcomes. Nonetheless, limitations include the single-center design, lack of long-term follow-up to assess recurrence, and absence of comparative arms with laser lithotripsy or SWL. Additionally, the study did not evaluate complication rates such as mucosal injury, infection, or need for stenting, which are relevant to the clinical decision-making process. Future research should aim to conduct multicenter, randomized controlled trials with longer follow-up periods to assess not only stone clearance but also recurrence rates, complication profiles, and cost-effectiveness. Moreover, direct comparisons between pneumatic and laser lithotripsy in similar clinical settings would be valuable in determining whether the increased cost of laser lithotripsy is justified by a clinically significant improvement in outcomes. Overall, the findings of this study reinforce the relevance of pneumatic lithotripsy as a feasible, effective, and economically appropriate intervention for proximal ureteric stones in underdeveloped healthcare environments.

CONCLUSION

Semi-rigid ureteroscopy combined with pneumatic lithotripsy proved to be a safe, reliable, and highly effective treatment option for adult patients with ureteric stones, regardless of stone size, location, or laterality. The procedure demonstrated consistent outcomes across different segments of the ureter, reinforcing its role as a practical and accessible intervention, particularly in resource-limited healthcare settings. These findings support the continued use of this technique as a first-line approach in the management of ureteric calculi, offering a valuable balance between efficacy, safety, and cost-effectiveness.

AUTHOR CONTRIBUTION

Author	Contribution
Siraj ul Islam*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Asif	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published

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