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Extracorporeal Shock Wave Lithotripsy, Ureterolithotripsy and Laparoscopic Uretrolithotomy in Treatment of Large Proximal Ureteral Stone

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ABSTRACT

Background: The proximal ureteral stone presents a difficult clinical entity which is an ongoing problem and necessitates the application of optimal treatment strategy in order to achieve satisfactory outcomes. Each of the available modalities, namely Extracorporeal Shock Wave Lithotripsy (ESWL), Ureterolithotripsy and Laparoscopic Ureterolithotomy, are efficient and safe with corresponding differences in therapeutic efficacy and safety profiles.

Objective: To compare the efficacy and clinical outcomes of ESWL, Ureterolithotripsy, and Laparoscopic Ureterolithotomy in the treatment of large proximal ureteral stones.

Material and Methods: This randomized controlled study was conducted in the Urology Department, Chandka Medical College, Larkana from June 2022 to May 2024. Total 75 patients with large proximal ureteral stones (≥10 mm) were selected for this study. Selected patients were randomized into three groups of 25 each: Ureterolithotripsy, ESWL, Laparoscopic Ureterolithotomy. Clinical parameters, including rate of stone clearance, time to stone clearance, hospital stay, pain score, and residual stones were examined. ANOVA and Chi-square tests determined statistical analysis at $p < 0.05$.

Results: Laparoscopic Ureterolithotomy achieved the highest stone clearance rate (100%), followed by Ureterolithotripsy (92%) and ESWL (44%) ($p < 0.001$). The time to stone clearance was shortest in the Laparoscopic group (8.00 ± 3.55 days) and longest in the ESWL group (17.88 ± 7.90 days) ($p < 0.001$). Pain scores were lowest in the Laparoscopic group (3.16 ± 1.14) and highest in the ESWL group (5.92 ± 1.29) ($p < 0.001$). Residual stones were significantly more frequent in the ESWL group (56%) compared to Ureterolithotripsy (8%) and Laparoscopic Ureterolithotomy (0%) ($p < 0.001$).

Conclusion: Laparoscopic Ureterolithotomy provides better efficacy with stone clearance for large proximal ureteral stones and Ureterolithotripsy is good alternatives, with less complications. However, ESWL is still a noninvasive option for select patients. A patient specific or resource available treatment option should be chosen.

Keywords: *Proximal ureteral stones, ESWL, Ureterolithotripsy, Laparoscopic ureterolithotomy, Stone clearance.*

1. INTRODUCTION

Large proximal ureteral stones pose a major dilemma to urologists as these are large, situated proximal to the ureteric orifice and carry a significant risk of complications. Often, these stones need customized treatment for best result and avoiding potential complications. Treatment can be envisaged for all three principal modalities of treatment: extracorporeal shock wave lithotripsy (ESWL), ureteroscopic lithotripsy (URS), and laparoscopic ureterolithotomy (LU) each with its advantages and limitations. [1]

Non invasive treatment of urinary stones like stones in kidneys, bladder and ureter (urinary tract) is being widely used for

treatment of urinary stones is ESWL. Good data exist showing that it has efficacy in clearing stones up to 20 mm in size but the reported success rates depend on stone size, composition, and anatomy. ESWL does not work well for larger stones for two reasons: complete fragmentation and clearing are difficult [1]. The value of advanced imaging and AI assisted technologies in enhancing fragmentation rates and retreatment rates [2] has also been studied more recently.

URS has emerged as a minimally invasive technique for the treatment of ureteral stones greater than 10 mm, and is often associated with laser lithotripsy, which permits precise fragmentation and extraction. As a consequence, URS is used with high stone clearance rates, though it mandates expertise to prevent complications of ureteral injury and postoperative complications [3]. The comparative studies have also shown superiority of URS over ESWL in larger proximal ureteral stones [4].

Although less commonly used, laproscopicurethrolithotomy is viable for large, impacted or challenging stone on anatomic grounds. Its stone free rates are very high, especially for stones > 20 mm, at the expense of being more invasive and requiring more recovery time than ESWL or URS. Rapid progress in minimally invasive surgery has made LU more safe and effective in select situations [5].

The appropriate treatment modality is selected based on stone characteristics, patient's anatomy, and one's expertise that is available. As noted in recent meta analyses, treatment strategies need to be tailored to individual patient profiles and more evidence based protocols employed [6]. The multimodal approach is considered in studies to overcome the limitations of individual techniques particularly when managing complex case except [7].

Advances in laser technology for URS, and the integration of AI in ESWL, holds promise for changing treatment paradigms. ESWL AI-assisted systems can optimize the delivery and targeting of these shockwave's; ESWL outcomes in larger stones [8] can be improved. Likewise, high power lasers are reported to be used in URS for fragmenting dense stones with little collateral injury to adjacent tissue [9].

Understanding of these modalities and their new roles in urological practice in the care of patients with large proximal ureteral stones is essential to maximize outcomes in those patients. Overcoming the challenge posed by this condition depends on continuous technological advancements, coupled with a patient centered approach [10].

Problems of proximal ureteral stones are due to their size and complication. Common procedures include ESWL, Ureterolithotripsy and Laparoscopic Ureterolithotomy, but success rates with patients vary. The aim of this study is to compare these modalities for selecting the most effective treatment regarding the stone clearance and the patient outcome

2. MATERIAL AND METHODS

To compare the efficacy and safety regarding large proximal ureteral stones treated either by Extracorporeal Shock Wave Lithotripsy (ESWL), Ureterolithotripsy, or Laparoscopic Ureterolithotomy, a prospective randomized controlled trial was conducted. It was done in Urology Department, Chandka Medical College, Larkana from June 2022 to May 2024.

The sample size was calculated based on the incidence of residual stones, with 33.33% in the ESWL group and 4.2% in the laparoscopic group, using a 95% confidence level and 80% power. A total of 75 participants (25 in each group) were included in the study [11].

Participants were included having age 18 to 65 years, diagnosed with a single, large proximal ureteral stone (size ≥5 mm), had no history of prior intervention for the current stone, and had normal renal function as determined by serum creatinine levels. Patients were excluded if they had multiple ureteral stones, active urinary tract infection or sepsis, coagulation disorders, contraindications to surgery, pregnancy, or severe obesity (BMI >35 kg/m²).

Participants were randomized into three equal groups (ESWL, Ureterolithotripsy, and Laparoscopic Ureterolithotomy) using a computer-generated randomization method. Allocation was concealed in sealed, opaque envelopes, which were opened at the time of intervention.

The three study groups were as follows:

- Group 1: Treated with ESWL.
- Group 2: Treated with Ureterolithotripsy.
- Group 3: Treated with Laparoscopic Ureterolithotomy.

The following variables were recorded and analyzed: Stone Clearance Rate (complete, partial, or failed removal of stones), Time to Stone Clearance (number of days to achieve stone-free status), Residual Stones (presence or absence of stone fragments post-treatment), Hospital Stay Duration (recorded in days), Pain Score (assessed using a Visual Analog Scale), Age, Gender, BMI, and Stone Size (measured in millimeters).

All patients underwent a detailed preoperative evaluation, including imaging via non-contrast computed tomography (NCCT)

to confirm stone size and location, and baseline investigations such as complete blood count, serum creatinine, and urinalysis. Post-treatment, patients were assessed for stone clearance via follow-up imaging (NCCT or ultrasound) at 1 week and 1 month. Residual stones were defined as stone fragments >3 mm detected on follow-up imaging. Pain scores were evaluated at 6 hours, 24 hours, and 7 days post-procedure. Additional assessments included complications (e.g., infection, bleeding, or ureteral injury) and hospital stay duration (number of days from admission to discharge).

Data were analyzed using SPSS Version 24. Continuous variables (e.g., stone size, pain score) were expressed as mean ± standard deviation (SD) and compared using ANOVA. Categorical variables (e.g., stone clearance, presence of residual stones) were presented as frequencies and percentages and analyzed using the Chi-square test. A p-value ≤ 0.05 was considered statistically significant.

3. RESULTS

A total of 75 patients participated in the study, divided evenly into three groups: ESWL, Laparoscopic Ureterolithotomy, and Ureterolithotripsy, with 25 patients in each group. The mean age of all participants was 40.73 ± 13.92 years, and the average BMI was 26.03 ± 4.42 kg/m². The mean stone size across all patients was 11.03 ± 4.18 mm. The average time to achieve stone clearance was 12.39 ± 7.02 days, with a mean hospital stay of 2.61 ± 1.15 days. The mean pain score reported by participants was 4.47 ± 1.63.

In the ESWL group, the average age was 41.04 ± 13.04 years, with a BMI of 26.19 ± 4.48 kg/m². The mean stone size was 10.92 ± 4.09 mm, while the average time to stone clearance was 17.88 ± 7.90 days. The mean hospital stay was 1.52 ± 0.51 days, and the pain score was 5.92 ± 1.29.

For the Laparoscopic Ureterolithotomy group, the mean age was 41.92 ± 15.35 years, and the BMI was 27.06 ± 4.67 kg/m². The mean stone size was 10.68 ± 4.17 mm, with a shorter average time to stone clearance of 8.00 ± 3.55 days. The mean hospital stay was longer at 3.92 ± 0.70 days, and the pain score was the lowest at 3.16 ± 1.14.

In the Ureterolithotripsy group, the average age was 39.24 ± 13.72 years, and the BMI was 24.83 ± 3.96 kg/m². The mean stone size was 11.48 ± 4.40 mm, with an average stone clearance time of 11.28 ± 4.90 days. The mean hospital stay was 2.40 ± 0.50 days, and the pain score was 4.32 ± 1.11.

A comparison of demographic and clinical variables (Table 1) showed no significant differences in age ($p = 0.791$), BMI ($p = 0.202$), or stone size ($p = 0.790$) among the groups. However, significant differences were noted for clinical outcomes. The Laparoscopic Ureterolithotomy group achieved the fastest time to stone clearance (8.00 ± 3.55 days), while the ESWL group required the longest (17.88 ± 7.90 days, $p < 0.001$). Hospital stay duration was shortest for ESWL (1.52 ± 0.51 days) and longest for Laparoscopic Ureterolithotomy (3.92 ± 0.70 days, $p < 0.001$). Pain scores were highest in the ESWL group (5.92 ± 1.29) and lowest in the Laparoscopic Ureterolithotomy group (3.16 ± 1.14, $p < 0.001$).

Table 2 compares stone clearance rates across the three groups. Complete clearance was achieved in 100% of cases in the Laparoscopic Ureterolithotomy group, 92% in the Ureterolithotripsy group, and 44% in the ESWL group. The differences in stone clearance rates were statistically significant ($p < 0.001$), highlighting the superior efficacy of Laparoscopic Ureterolithotomy.

Table 1: Comparison of Demographic and Clinical Variables among ESWL, Ureterolithotripsy, and Laparoscopic Ureterolithotomy Groups

Variable	ESWL (Mean ± SD)	Ureterolithotripsy (Mean ± SD)	Laparoscopic Ureterolithotomy (Mean ± SD)	p-value
Age	41.04 ± 13.04	39.24 ± 13.72	41.92 ± 15.35	0.791
BMI	26.19 ± 4.48	24.83 ± 3.96	27.06 ± 4.67	0.202
Stone Size (mm)	10.92 ± 4.09	11.48 ± 4.40	10.68 ± 4.17	0.790
Time to Stone Clearance (Days)	17.88 ± 7.90	11.28 ± 4.90	8.00 ± 3.55	<0.001
Hospital Stay (Days)	1.52 ± 0.51	2.40 ± 0.50	3.92 ± 0.70	<0.001
Pain Score	5.92 ± 1.29	4.32 ± 1.11	3.16 ± 1.14	<0.001

Table 2: Comparison of Stone Clearance Rates among ESWL, Ureterolithotripsy, and Laparoscopic Ureterolithotomy Groups

Group	Complete Clearance (n, %)	Incomplete Clearance (n, %)	p-value
ESWL	11 (44%)	14 (56%)	**<0.001**
Ureterolithotripsy	23 (92%)	2 (8%)	
Laparoscopic Ureterolithotomy	25 (100%)	0 (0%)	

4. DISCUSSION

The results of this study highlight significant differences in the efficacy and outcomes of three treatment modalities for large proximal ureteral stones: Ureterolithotripsy extracorporeal shock wave lithotripsy (ESWL,) and laparoscopic ureterolithotomy. We find that these findings agree with and augment the current literature from an overall perspective and compare these techniques.

The highest success rate in stone clearance was with Laparoscopic Ureterolithotomy (1000%), followed by Ureterolithotripsy (92%) and ESWL (44%). In line with this, Shamma et al. reported less residual stones in the laparoscopic cases (4.2%) than ESWL group (33.33%) [11]. Laparoscopic ureterolithotomy has well documented superiority in single session stone clearance and it is preferred approach for large proximal ureteral stones when resources allow.

Laparoscopic ureterolithotomy had a similar success rate reported by Imran et al., 90%, compared to 64.3% for Ureterolithotripsy and 37.5% for ESWL [12]. In addition, they observed fewer treatment sessions for laparoscopic ureterolithotomy, which is consistent with our observation that stones clear more quickly in this group. Larger stones could thus be successfully treated laparoscopically with the shorter time to stone free status further enhancing its efficacy.

A study by Tareen and Nasir corroborates our findings, reporting a 94.12% success rate for laparoscopic ureterolithotomy, compared to lower rates for ESWL and Ureterolithotripsy [13]. The significant differences in stone clearance rates can be attributed to the direct and minimally obstructed access provided by laparoscopic procedures, which is especially beneficial for large or impacted stones. However, this modality is associated with a longer hospital stay and increased postoperative discomfort, as seen in our study and others [11, 12].

The limitations of ESWL in treating large stones have been extensively discussed in the literature. Neto et al. demonstrated that ESWL had a success rate of only 35.7%, significantly lower than 93.3% for laparoscopic ureterolithotomy [14]. The higher incidence of residual stones with ESWL necessitates repeated sessions, increasing the overall burden on patients. This aligns with our findings, where ESWL required the longest time to achieve stone clearance and resulted in the highest pain scores among the three groups.

Postoperative pain is an important consideration in evaluating treatment modalities. Our study revealed that the ESWL group experienced the highest pain scores (mean 5.92), while laparoscopic ureterolithotomy was associated with significantly lower pain (mean 3.16). Similar findings were reported by Asadullah et al., who noted increased postoperative pain and longer hospital stays with laparoscopic procedures, albeit with superior stone clearance [15]. The trade-off between effectiveness and patient comfort is a critical factor in clinical decision-making.

Bahceci et al. highlighted that while ESWL remains a cost-effective option for smaller stones, its efficacy decreases significantly for stones >10 mm, favoring ureterolithotripsy or laparoscopic approaches for larger stones [16]. This finding is consistent with our study, which focused exclusively on large proximal ureteral stones (≥10 mm). Ureterolithotripsy emerged as a reliable intermediary technique, balancing efficacy and patient comfort with a success rate of 92%.

Sharma et al.'s meta-analysis further supports our results, concluding that laparoscopic ureterolithotomy offers the highest stone-free rates among all techniques for large ureteral stones [17]. Their analysis emphasized the need for auxiliary treatments in ESWL, which was also evident in our findings, where the ESWL group required additional procedures more frequently than the other groups.

Ali et al. provided additional insights into the safety and efficacy of laparoscopic ureterolithotomy, reporting comparable complication rates with ureteroscopic lithotripsy but significantly higher stone-free rates [18]. This is consistent with our observation that laparoscopic procedures, while effective, require careful patient selection and institutional expertise to minimize complications.

Kaygısız et al. compared ureteroscopic laser lithotripsy with laparoscopic ureterolithotomy and found similar stone-free rates at three months post-treatment but noted higher first-attempt success rates with laparoscopic techniques [19]. This supports

the notion that laparoscopic ureterolithotomy remains a superior option for immediate and reliable stone clearance.

A systematic review comparing shock wave lithotripsy (SWL) to ureteroscopic lithotripsy (URSL) concluded that URSL provided a higher stone free rate and retreat rate than SWL [20]. Our results replicate these findings and reinforce the limitations of ESWL for achieving good outcome for large proximal ureteral stones.

These findings hold important overall clinical implications. While resource intensive, laparoscopic ureterolithotomy is unrivaled in the effectiveness with which large proximal ureteral stone are managed. Ureterolithotripsy represents an effective alternative with less complications and greater patient comfort. Although larger stones are less likely to be successfully ignored, ESWL can be considered for patients unable to have an invasive procedure. Treatment choice should be adjusted to patient specific factors such as stone size and location, comorbidities and resources available to the individual.

5. CONCLUSION

Large proximal ureteral stones remain a difficult clinical problem because of the size and location of the stone, as well as the propensity for the stone to cause obstruction and renal damage. Multiple treatment modalities exist which include Extracorporeal Shock Wave Lithotripsy (ESWL), Ureterolithotripsy, and Laparoscopic Ureterolithotomy, however, there is substantial inter variability with the treatment efficacy and safety, and the way patient outcomes are dealt with. Non obstructive stones can be treated by ESWL, which is non invasive but generally associated with lower stone clearance rates in larger stones; ureterolithotripsy and laparoscopic ureterolithotomy are more invasive, but have a higher success rates. Without consensus on the optimal approach to large proximal ureteral stones, this study attempts to evaluate these techniques comparatively with regard to critical clinical endpoints including stone clearance rates, residual stones, pain scores, and hospital stay. The findings will help clinicians choose the most effective and patient centered treatment modality to fill an important gap in evidence based urological practice.

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