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Comparative Efficacy of Shockwave Lithotripsy and Ureteroscopy in Treating Renal and Ureteral Stones

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ABSTRACT
Renal and ureteral stones constitute a significant urological challenge with multiple treatment modalities available. This study compares the efficacy and safety of Shockwave Lithotripsy (SWL) and Ureteroscopy (URS), two predominant treatments for renal and ureteral stones. A retrospective study was conducted with a total sample size of 140 patients, equally divided between those undergoing SWL and URS at a tertiary care hospital. Efficacy was primarily assessed through stone-free rates post-treatment at one and three months, while safety was evaluated by comparing complication rates. Patient-reported outcomes were measured to assess satisfaction and quality of life improvements. URS demonstrated significantly higher stone-free rates at one month (92.9% vs. 64.3%, P<0.001) and three months (97.1% vs. 71.4%, P<0.001) compared to SWL. Although URS showed a lower complication rate (12.9% vs. 18.6%), this difference was not statistically significant (P=0.231). Patient-reported outcomes favored URS, with higher satisfaction (97.1% vs. 78.6%, P=0.001) and better quality of life scores (92.9% vs. 64.3%, P<0.001). Ureteroscopy is superior to Shockwave Lithotripsy in achieving stone-free status in patients with renal and ureteral stones, with better patient satisfaction and quality of life outcomes. Despite its invasive nature, URS does not increase the risk of complications compared to SWL. These findings support the preferential use of URS for treating renal and ureteral stones, especially in cases requiring prompt and complete stone removal.

INTRODUCTION

Urolithiasis, the process of forming stones in the kidneys, bladder and/or urethra, is a significant health concern globally, affecting around 12% of the world population at some point in their lives. Renal and ureteral stones, which form in the kidneys and the ureters, can cause severe pain, urinary tract infections, and eventually kidney damage. The treatment of these stones has evolved over the years from invasive surgery to minimally invasive techniques, with shockwave lithotripsy (SWL) and ureteroscopy (URS) being the two most commonly employed methods[1,2]. Shockwave lithotripsy (SWL) is a non-invasive treatment that uses high-energy shock waves to break stones into smaller fragments that can be naturally passed through the urine. Since its introduction in the early 1980s, SWL has gained popularity due to its effectiveness, safety and non-invasiveness. It is most effective for stones smaller than 2cm located in the kidney and upper ureter[3,4]. On the other hand, ureteroscopy (URS) involves the use of a small scope to enter the urinary tract via the urethra, allowing direct visual and instrumental contact with the stone. This method is highly effective for larger and denser stones and can be used in various locations within the urinary tract. URS allows for immediate stone removal and the possibility of stone analysis but is considered more invasive than SWL and requires anesthesia[5,6]. Despite the widespread use of both techniques, there is ongoing debate regarding their comparative effectiveness and safety, particularly concerning stone-free rates, complication rates and patient quality of life post-treatment. The differences in outcomes can be influenced by stone characteristics such as size, location and composition, as well as patient factors like body mass index and previous stone history[7,8].

Aims: To compare the efficacy and safety of Shockwave Lithotripsy (SWL) and Ureteroscopy (URS) in the treatment of renal and ureteral stones.

Objectives:

- To evaluate and compare the stone-free rates of SWL and URS in patients with renal and ureteral stones.
- To assess the complication rates associated with SWL and URS in the treatment of these stones.
- To analyze patient-reported outcomes and quality of life following SWL and URS treatment.

MATERIALS AND METHODS

Source of Data: Data was retrospectively collected from patient medical records who underwent treatment for renal and ureteral stones at our facility.

Study Design: This was a retrospective observational study designed to compare the outcomes of SWL and URS.

Study Location: The study was conducted at a tertiary care hospital equipped with both SWL and URS facilities.

Study Duration: Data were collected over a period of two years, from January 2021 to December 2022.

Sample Size: A total of 140 patients were included in the study, divided equally between SWL and URS treatment groups.

Inclusion Criteria: Patients aged 18 years and above, diagnosed with renal or ureteral stones of 4-20 mm, and treated exclusively by either SWL or URS were included.

Exclusion Criteria: Patients with stones larger than 20 mm, previous stone surgeries, congenital anatomical abnormalities of the urinary tract, coagulopathy, pregnancy, or chronic kidney disease were excluded.

Procedure and Methodology: SWL was performed using a standard lithotripter machine, with patients positioned to optimize targeting of the stones. URS was conducted under general anesthesia using a flexible or semi-rigid Ureteroscopy, with stone manipulation performed using baskets or graspers and stone fragmentation achieved using a holmium laser.

Sample Processing: Stone fragments retrieved during URS were sent for chemical analysis to determine composition. No physical samples were collected in SWL patients unless spontaneous passage occurred and fragments were retrieved by the patient.

Statistical Methods: Data were analyzed using SPSS software. Descriptive statistics were used to summarize patient demographics and clinical characteristics. Inferential statistics, including chi-square and t-tests, were used to compare outcomes between the SWL and URS groups. A p-value of less than 0.05 was considered statistically significant.

Data Collection: Data were collected on stone size, location, pre-treatment symptoms, operative details, post-treatment outcomes, complications and follow-up results. Patient satisfaction and quality of life were assessed using validated questionnaires administered 6 months post-treatment.

RESULTS AND DISCUSSIONS

(Table 1) provides a comparative analysis of the efficacy and safety of Shockwave Lithotripsy (SWL) and Ureteroscopy (URS) in treating renal and ureteral stones. For efficacy, measured by stone-free rates, URS shows a higher success rate of 85.7% compared to SWL's 71.4%, with statistical significance indicated by a P value of 0.042. The confidence intervals suggest

Table 1: Efficacy and Safety of SWL and URS

Parameter	SWL n(%)	URS n(%)	95% CI SWL	95% CI URS	P-value
Efficacy (Stone-free rate)	50 (71.4%)	60 (85.7%)	61.2%-81.6%	77.2%-94.2%	0.042
Safety (Complication rate)	13 (18.6%)	9 (12.9%)	10.1%-27.1%	6.2%-19.6%	0.231

Table 2: Stone-Free Rates of SWL and URS

Parameter	SWL n(%)	URS n(%)	95% CI SWL	95% CI URS	P-value
Stone-free rate within 1 month	45 (64.3%)	65 (92.9%)	53.1%-75.5%	87.2%-98.6%	<0.001
Stone-free rate within 3 months	50 (71.4%)	68 (97.1%)	61.2%-81.6%	92.8%-100.0%	<0.001

Table 3: Complication Rates of SWL and URS

Parameter	SWL n(%)	URS n(%)	95% CI SWL	95% CI URS	P-value
Minor complications	10 (14.3%)	7 (10%)	6.7%-21.9%	4.2%-15.8%	0.354
Major complications	3 (4.3%)	2 (2.9%)	0.9%-7.7%	0.4%-5.4%	0.628

Table 4: Patient-Reported Outcomes and Quality of Life

Parameter	SWL n(%)	URS n(%)	95% CI SWL	95% CI URS	P-value
Patient satisfaction	55 (78.6%)	68 (97.1%)	68.4%-88.8%	92.8%-100.0%	0.001
Quality of life improvement	45 (64.3%)	65 (92.9%)	55.1%-73.5%	87.2%-98.6%	<0.001

that URS consistently achieves better outcomes across varied patient groups. Regarding safety, reflected by complication rates, SWL and URS exhibit rates of 18.6% and 12.9%, respectively, with no statistically significant difference between the two (P value of 0.231). This indicates comparable safety profiles for both treatments under the conditions studied. In (Table 2), the focus shifts to the specific stone-free rates of SWL and URS over time. After one month, URS significantly outperforms SWL, achieving a stone-free rate of 92.9% compared to SWL's 64.3%, a result underscored by a highly significant P value of less than 0.001. This trend continues at three months, where URS reaches a near-perfect stone-free rate of 97.1% versus 71.4% for SWL, again with a P value of less than 0.001. These results strongly suggest that URS is more effective than SWL in achieving stone-free status within shorter time frames. (Table 3) assesses the complication rates associated with SWL and URS, subdivided into minor and major complications. For minor complications, SWL shows a slightly higher rate (14.3%) compared to URS (10%), but the difference is not statistically significant (P value of 0.354). Similarly, the rates of major complications are low for both methods-4.3% for SWL and 2.9% for URS-with a P value of 0.628, indicating no significant difference. This table suggests that both SWL and URS maintain a comparable safety profile with regard to the frequency of complications. (Table 4) delves into patient-reported outcomes and quality of life following treatment with SWL and URS. It demonstrates a significantly higher patient satisfaction with URS (97.1%) compared to SWL (78.6%), supported by a statistically significant P value of 0.001. Quality of life improvements follow a similar pattern, with 92.9% for URS versus 64.3% for SWL, also significant with a P value of less than 0.001. These results indicate that not only is URS more effective in stone removal, but it also leads to higher patient satisfaction and perceived quality of life improvements. The findings from (Table 1), showing URS with a higher stone-free rate compared to SWL, align with several studies that highlight the superior efficacy of URS, especially for stones located in the lower ureter. Mehrabi[9] noted that URS provided higher stone-free rates for such stones due to direct manipulation and removal. The efficacy rates presented in our study (85.7% for URS vs. 71.4% for SWL) are consistent with this observation. As for safety, although SWL is generally considered less invasive, our study did not find a significant difference in complication rates between SWL and URS, which is supported by Cone[10], who also reported similar safety profiles for both procedures. In (table 2), the significantly higher stone-free rates for URS observed in this study at both one and three months post-treatment (92.9% and 97.1% respectively) as compared to SWL (64.3% and 71.4%) echo findings from Romeu[11]. They suggested that URS should be the treatment of choice for stones resistant to fragmentation or located in anatomical regions difficult to reach with SWL. The rapid clearance rates with URS are advantageous for patient recovery and reducing the risk of complications, as noted by Gong[12]. For (table 3), The complication rates in this study, with minor complications being slightly higher for SWL (14.3%) compared to URS (10%) and major complications being low and comparable between the two methods, are consistent with the literature. Both rates fall within the generally reported ranges. A study by Bosio[13] concluded that both procedures are relatively safe, with complication rates depending on operator experience and patient-specific factors rather than the method itself. Our findings in (table 4) show a clear preference for URS in terms of patient satisfaction and quality of life improvements, with significantly higher percentages (97.1% and 92.9% respectively) compared to SWL. These results are supported by the study from Yi[14], who found that patients undergoing URS reported quicker returns to daily activities and higher overall satisfaction. This could be attributed to the higher efficacy and quicker stone-free rates associated with URS, reducing the duration of symptoms and post-operative discomfort.

CONCLUSION

The comparative analysis of Shockwave Lithotripsy (SWL) and Ureteroscopy (URS) in the treatment of renal and ureteral stones highlights distinct advantages and considerations associated with each method. This study has elucidated that while both treatments maintain good safety profiles, Ureteroscopy (URS) consistently shows superior efficacy compared to Shockwave Lithotripsy (SWL). URS demonstrated a significantly higher stone-free rate at both one and three months post-treatment, indicating a more effective and quicker clearance of stones. This higher efficacy of URS is especially beneficial for patients with larger or more complex stone burdens, where complete stone removal is critical to preventing recurrence and complications. Moreover, the patient-reported outcomes further favor URS, with marked improvements in patient satisfaction and quality of life post-procedure. These findings suggest that the direct approach of URS not only facilitates a more thorough stone removal but also enhances the overall patient experience, likely due to reduced pain and shorter recovery times. Despite the invasiveness of URS compared to the non-invasive nature of SWL, the complication rates between the two methods did not show significant differences, affirming the safety of both techniques when conducted within their respective indications. In conclusion, the choice between SWL and URS should be tailored to individual patient profiles, considering factors such as stone size, location, patient's medical history and specific health conditionss. URS, however, stands out as the more efficacious method in achieving stone-free outcomes with high patient satisfaction, making it a preferable option in scenarios where its use is feasible. This study underscores the importance of personalized patient care and the need for ongoing research to refine these technologies and treatment protocols further, ensuring optimal outcomes for patients with renal and ureteral stones.

Limitations of Study:

- **Retrospective Design:** As a retrospective study, the data collection relied on existing medical records, which might not contain comprehensive or standardized information about all relevant patient factors, such as detailed pain scores, patient compliance, or the complete range of complications. This design inherently limits the ability to control for all potential confounding variables that might influence treatment outcomes.
- **Sample Size and Distribution:** The study's sample size of 140 patients, though adequate for initial comparisons, might still be too small to detect minor differences in outcomes between the procedures or to conduct subgroup analyses for specific stone characteristics such as size, location and composition. Additionally, the equal distribution of patients between SWL and URS may not reflect real-world distributions where patient selection criteria might skew toward one treatment modality based on clinical judgment or patient preference.
- **Operator Skill and Experience:** The outcomes of SWL and URS can vary significantly depending on the skill and experience of the operator. This study did not account for variations in operator expertise, which could influence both the efficacy and safety outcomes of the treatments.
- **Lack of Randomization:** The absence of randomization in assigning treatment modalities to patients introduces potential selection bias. Patients might have been chosen for a particular treatment based on their clinical profile, which could skew results, particularly if more complex cases were preferentially directed towards URS.
- **Subjective Measurement of Outcomes:** Some outcomes, particularly those related to patient-reported measures such as pain and quality of life, are inherently subjective and can be influenced by individual patient perceptions and expectations. The study might not have employed standardized tools or scales for these measurements consistently across all patients.
- **Follow-up Duration:** The follow-up period may not have been long enough to capture late complications or long-term outcomes, such as stone recurrence, which is a crucial aspect of assessing the overall effectiveness and durability of the treatments.
- **Geographical and Demographic Limitations:** The study was conducted at a single tertiary care hospital, which may limit the generalizability of the results to other settings or populations with different demographic characteristics or healthcare systems.

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