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OUTCOMES OF EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY (ESWL) FOR BLADDER STONE LESS THAN 2CM IN SIZE

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ABSTRACT

OBJECTIVE

To determine the outcome of extracorporeal shock wave lithotripsy (ESWL) for bladder stones less than 2cm in size.

METHODOLOGY

The study was conducted in the Department of Urology at the Sindh Institute of Urology and Transplantation (SIUT) Karachi. A non-probability consecutive sampling technique was used to enroll the sample of 113 patients between 20 and 70 years of age, either gender, with single renal stones less than 2 cm in size. ESWL was performed by using a Storz Modulith Electromagnetic lithotripter (Karl Storz Lithotripsy-America Inc, Atlanta, GA), with stones localized by ultrasound and fluoroscopy. Treatment involved administering 200 shock waves at energy levels 2–3 per minute, followed by 3000 shocks at levels 4–6 at a rate of 70–90 per minute. Patients were advised to maintain adequate oral fluid intake and were followed up at two weeks, four weeks, and finally at eight weeks to assess the efficacy. The SPSS version 26.0 was used to evaluate the data.

RESULTS

The mean ± standard deviation of the sample of 113 patients was noted as 40.71 ± 10.78 years. Among them 69.9% were male while 30.1% were female. The average stone size was 8.85 ± 3.14 mm, the stone size between 4 to 9 mm represented 73.5% of patients and > 9 mm represented 26.5% of patients. The stone clearance was achieved in 69.9% patients while 30.1% had residual stones. Patients with a skin-to-stone distance of 70–125 mm had a significantly higher clearance rate of 74.7% compared to 50.0% in those with a skin-to-stone distance >125 mm (OR: 2.957, p = 0.023).

CONCLUSION

It is concluded that ESWL) is a safe and efficient treatment modality for bladder stones smaller than 2 cm. Successful stone clearance was independently predicted by BMI, skin-to-stone distance and the ESWL score. Outcomes were not significantly affected by age, stone size, gender or stone location. These results highlight the need to individualize patient factors for optimal ESWL outcomes.

KEYWORDS

Extracorporeal shock wave lithotripsy, Bladder stones, Stone clearance, Stone size < 2cm

INTRODUCTION

Extracorporeal shock wave lithotripsy (ESWL) is the most advanced technology for urinary stone treatment, especially in the case of bladder stones. Since ESWL is a widely used non-invasive procedure for stones <2 cm, its effectiveness, complications and long-term outcomes is of importance when taking decisions in clinical practice.

The ESWL efficacy have been extensively tested from different studies that bring out positive results in the fragment and clearance of the bladder stones. A systematic review, for example, emphasized that ESWL achieves a significant stone-free rate in patients with stones < 2cm, similar to other interventional modalities like percutaneous nephrolithotomy and ureteroscopy, but with lower morbidity [1]. Moreover, success rates with ESWL can vary significantly based on other variables including stone composition, patient anatomy, and procedure parameters [2,3].

Compared with more aggressive interventions, the ESWL complication profile is relatively superficial. Short-term problems include passage of blood, pain and some mild renal colic. Although infrequent, significant adverse events include nephritis or nephrotoxicity. Configuration of preoperative assessment and adjustment of the treatment parameters according to individual patient characteristics can help increase the predictability of the complications of the ESWL [4,5].

Above all, an analysis examining the safety and effectiveness of the ESWL against flexible ureteroscopy has echoed the trend that if complications can occur, they are often less serious than those associated with surgical methods [6].

Long-term results after post-ESWL treatment for bladder stones remain a subject of interest, in particular with regard to recurrence rates and quality of life after the procedure. The evidence indicates that although initial abandonment rates can be high a subset of patients experiences recurrent stone formation, requiring continuous monitoring and potential reprocessing [7,8]. These recurrences are influenced by various factors, including metabolic conditions and membership of preventive measures. In addition, an analysis suggests that although the ESWL cannot prevent the future formation of stones, it considerably improves the quality of life of individuals by attenuating the symptoms linked to stone [9].

By exploring the cost of ESWL for the treatment of urinary stones, studies have also focused on economic considerations that could influence the selection of treatment. To date, a recent comparative investigation detected a cost-effective application for ESWL in the management of stones with a size of fewer than 2cm, specifically in health system with restricted health assets [10]. This is a key economic consideration for decision-makers and health practitioners when deciding treatment protocols for bladder calculi.

The ever-evolving technological innovations and strategies are still making ESWL better and safer since Its advent. Future innovations will continue to improve the delivery of shockwaves, including ultrasound-facilitated lithotripsies, as well as targeting systems that can increase success rates whilst minimizing complications [11]. With the current refinements, the adjustment of ESWL parameters according to a thorough insight into the individual factors of patients will be a part of the treatment results [12].

High Extracorporeal Shock Wave Lithotripsy (ESWL) efficiency and low complications confirms ESWL as an effective and safe method for the management of the stones of lower urinary tract (bladder) less than 2 cm.

Although the procedure has high initial stone rates, the recurrence potential requires continuous monitoring and education of patients to mitigate the formation of future stones. As advances occur in the field the evolutionary landscape of ESWL can potentially improve clinical and economic results in the management of bladder stones. Thus, current research and clinical examination are essential to refine these approaches and optimize patient care [13,14].

METHODOLOGY

The study was conducted in the Department of Urology at the Sindh Institute of Urology and Transplantation (SIUT) Karachi, after taken ethical approval from the institutional review committee of the institute. This descriptive cross-sectional study was conducted from May 2024 to November 2024. A non-probability consecutive sampling technique was used to recruit the sample of 113 patients between 20 and 70 years of age, either gender, with single renal stones less than 2 cm in size, visible on

ultrasound, who were scheduled for ESWL were included in the study after taken written informed. Exclusion criteria included patients with a history of dialysis, benign prostatic hyperplasia, end-stage renal disease, unsuccessful ESWL, ureteral stents, radiolucent stones, stroke, chronic liver or renal diseases, cardiovascular conditions, or pregnancy confirmed by a dating scan.

Each participant underwent a detailed history and clinical examination, including an assessment of presenting complaints, stone history, medical background, and dietary habits, along with a focused abdominal and genitourinary examination to evaluate for tenderness, guarding, or abnormalities. Neurological and systemic examinations, including vital signs and hydration status, were also performed. Laboratory investigations, such as complete blood count, blood sugar, urea, serum creatinine, and urine routine analysis, were conducted to assess infection, inflammation, and renal function. Diagnosis and stone characterization were confirmed through radiological investigations, including X-ray KUB, urinary ultrasound, and computed tomography.

ESWL was performed by using a Storz Modulith Electromagnetic lithotripter (Karl Storz Lithotripsy-America Inc, Atlanta, GA), with stones localized by ultrasound and fluoroscopy. Treatment involved administering 200 shock waves at energy levels 2–3 per minute, followed by 3000 shocks at levels 4–6 at a rate of 70–90 per minute. Intravenous painkillers were administered for patients experiencing pain. Patients were advised to maintain adequate oral fluid intake and were followed up at two weeks, four weeks, and finally at eight weeks. Efficacy was assessed at eight weeks, defined as complete clearance of the stone with no residual fragments on follow-up plain X-ray KUB. SPSS version 26.0 was used to analyse the data. Descriptive statistics which include mean ± standard deviation and frequency with percentage was calculated for quantitative and qualitative variable respectively. Inferential statistics was calculated by using Chi-square test at 5% level of significance.

RESULTS

The participants in the study were 113 in total and their average age was 40.71 ± 10.78 years old. Of those 54.9% were between 20 and 40 years and 45.1% were > 40 years. The average BMI was noted as 26.69 ± 3.65 kg/m² among them 53.1% between 20 to 26 and 46.9% >26 kg/m². The average stone size was 8.85 ± 3.14 mm, the stone size between 4 to 9 mm represented 73.5% of patients and > 9 mm represented 26.5% of patients. The average distance from the skin to the stone was 123.94 ± 34.91 mm; 51.3% were in the 70 to 125 mm range and 48.7% were >125 mm. Males comprised 69.9% of the participants, while females accounted for 30.1%. Regarding stone site, 54.0% were on the right side and 46.0% on the left. The most common stone location was the renal pelvis (50.4%), followed by the middle calyx (20.4%), lower calyx (18.6%), and upper calyx (10.6%). The ESWL score distribution showed that 8.8% had a score of 0, 21.2% had a score of 1, 42.5% had a score of 2, and 27.4% had a score of 3 as shown in TABLE I.

Table II summarizes the characteristics of patients with stone clearance, showing that 79 (69.9%) patients achieved stone clearance, while 34 (30.1%) had residual stones. Patients with a BMI of 20–26 kg/m² had a significantly higher stone clearance rate of 81.7% as compared to BMI >26 kg/m² which was accounted for 56.6% participants with (OR 3.415, p = 0.004). Additionally, those with a skin-to-stone distance of 70–125 mm had a significantly higher clearance rate of 74.7%, compared to 50.0% in patients with skin-to-stone distances > 125 mm (OR 2.957, p = 0.023). Age, stone size, gender, and stone site did not show statistically significant differences in clearance rates. On the other hand, patients with left sided stones tended to have a better stone clearance rate which was accounted 78.8% than those with right-sided stones 62.3% demonstrating a borderline statistical significance (OR: 2.256 and p = 0.056). In terms of stone location, the clearance rates were higher for middle 82.6% followed by lower calyx 85.7%, pelvis 61.4% and upper calyx 58.3% with insignificant difference was noted (P > 0.05). The ESWL score was also independently and significantly associated with stone-free status (p = 0.046).

DISCUSSION

Extracorporeal Shock Wave Lithotripsy is a widely recognized non-invasive procedure, used for the treatment of urinary stones including bladder stones, especially those less than 2 cm [15]. The procedure uses high-energy shock waves to break stone into smaller fragments which then can be passed through the urinary tract while ESWL is commonly associated with kidney stones, its application in bladder stone treatment offers an alternative to more invasive procedures such as cystolithotomy [16]. The biggest benefit of ESWL is that is performed as an outpatient procedure and does not involve any incisions or entrance directly into the bladder, greatly reducing the risk of infection, bleeding and other complications. Using ESWL usually requires only local anesthesia or sedation, so it is less invasive than the surgery [17]. The procedure is less painful for the patients, who can resume regular life soon after, making it even more attractive.

Lithotripsy has shown great efficacy for the treatment of bladder stones smaller than 2 cm, being reported as between over 85% and 90% effective [18]. The stones are of the composition that they break easier, as example, uric acid stones are softer in composition. Limited morbidity, and rapid recovery [19] makes ESWL an appealing first line treatment option for these small bladder stones. However, there are few drawbacks to be kept in mind although the complication risks such as severe bleeding or damage to local organs is significantly lower than with conventional surgical methods.

The procedure's efficacy may be reduced for harder stones, such as those made of calcium oxalate or cystine, which may not fragment as effectively, this could need additional treatments or interventions and in a few cases the stone may not be fully broken down leading to the requirement for substitute treatments.

The ESWL, despite being quite a safe treatment strategy, can still lead to complications, such as constructing small stone fragments that may cause urinary obstruction or discomfort. Hematuria or blood in the urine is another common side effect that while usually mild and temporary, may require observation [20]. In some cases, urinary tract infections may develop, especially if post-treatment care is not followed carefully. ESWL is also not suitable for all patients; for example, those with certain anatomical abnormalities or those who have implanted medical devices like pacemakers may not be good candidates for the procedure.

In our study, the stone clearance rate was noted in 79 (69.9%) of patients. The study conducted by Nielsen TK, et al stated that the first ESWL success rate was 69%, but following repeated treatment, it was 93% [21]. In another study, the overall success rate of ESWL was reported to be 82.6% effective in individuals with stones under 2cm [22]. The study by Rasheed Y, et al reported the ESWL stone free rate of 68% [23].

The strengths of ESWL remain in its non-invasive nature, minimal recovery time and high success rate for smaller stones, particularly those of soft composition. It provides an alternative to more invasive surgeries reducing the risk of complications and improving patient outcomes. However, its limitations were reduced efficacy for harder stones, and the capacity for fragmentation-related issues such as obstruction or infection. Also, patients with anatomical or medical device concerns may not be feasible participants for ESWL.

While this can be associated with excellent outcomes there needs to be careful patient selection. For bladder stones smaller than 2 cm in size, especially those comprising of soft material, ESWL is ideal. If there is any possibility that the patient might not be a suitable candidate for ESWL, pre-treatment imaging with ultrasound or CT should be performed to assess stone size, composition and location. Follow-up is furthermore essential to guarantee the little stone bits eliminate well and to fit complications, such as an hinders or infection. Recurrent stones or stones that are resistant to ESWL (extracorporeal shock-wave lithotripsy) should be managed by other treatments, such as laser lithotripsy or cystolithotomy.

Extracorporeal shock wave lithotripsy has been a very effective and minimally invasive treatment option for patients with smaller bladder stones (<2 cm) and proper patient selection with aftercare to optimize stone clearance can yield a relatively safe, effective and economical alternative to more invasive techniques while not necessarily being suitable for all patients or stone types.

CONCLUSION

It is concluded that extracorporeal shock wave lithotripsy (ESWL) is a safe and efficient treatment modality for bladder stones smaller than 2 cm. Successful stone clearance was independently predicted by BMI, skin-to-stone distance and the ESWL score. Outcomes were not significantly affected by age, stone size, gender or stone location. These results highlight the need to individualize patient factors for optimal ESWL outcomes.

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Table I: Characteristics of Study Participants (n=113)	
Variable	**n (%)**
Age (Mean ± SD) = 40.71 ± 10.78	
20 - 40 years	62 (54.9)
>40 years	51 (45.1)
BMI (Mean ± SD) = 26.69 ± 3.65	
20 - 26 kg/m^2	60 (53.1)
>26 kg/m^2	53 (46.9)
Stone Size (Mean ± SD) = 8.85 ± 3.14	
4 - 9 mm	83 (73.5)
>9 mm	30 (26.5)
Skin-to-Stone Distance (Mean ± SD) = 123.94 ± 34.91	
70 - 125 mm	58 (51.3)
>125 mm	55 (48.7)
Gender	
Male	79 (69.9)
Female	34 (30.1)
Site of Stone	
Left	52 (46.0)
Right	61 (54.0)
Location of Stone	
Pelvis	57 (50.4)
Upper Calyx	12 (10.6)
Middle Calyx	23 (20.4)
Lower Calyx	21 (18.6)
ESWL Score	
0	10 (8.8)
1	24 (21.2)
2	48 (42.5)
3	31 (27.4)

Table II: Characteristics of Patients with Stone Clearance (n=113)

Variables		Stone Clearance		OR 95% C. I	P-Value
		Free (n=79)	Residual (n=34)		
Age Group	20 - 40 years, *n* (%)	47 (75.8)	15 (24.2)	1.860 (0.826----4.192)	0.132
	>40 years, *n* (%)	32 (62.7)	19 (37.3)		
BMI Group	20 - 26 kg/m^2, *n* (%)	49 (81.7)	11 (18.3)	3.415 (1.460----7.991)	0.004*
	>26 kg/m^2, *n* (%)	30 (56.6)	23 (43.4)		
Stone Size	4 - 9 mm, *n* (%)	61 (73.5)	22 (26.5)	1.848 (0.768----4.448)	0.167
	>9 mm, *n* (%)	18 (60.0)	12 (40.0)		
Skin-to-Stone Distance	70 - 125 mm, *n* (%)	68 (74.7)	23 (25.3)	2.957 (1.132----7.723)	0.023*
	>125 mm, *n* (%)	11 (50.0)	11 (50.0)		
Gender	Male, *n* (%)	56 (70.9)	23 (29.1)	1.164 (0.489----2.771)	0.731
	Female, *n* (%)	23 (67.6)	11 (32.4)		
Site of Stone	Left, *n* (%)	41 (78.8)	11 (21.2)	2.256 (0.971----5.243)	0.056
	Right, *n* (%)	38 (62.3)	23 (37.7)		
Location of Stone	Pelvis, *n* (%)	35 (61.4)	22 (38.6)	0.629 (0.430----0.919)	0.072
	Upper Calyx, *n* (%)	7 (58.3)	5 (41.7)		
	Middle Calyx, *n* (%)	19 (82.6)	4 (17.4)		
	Lower Calyx, *n* (%)	18 (85.7)	3 (14.3)		
ESWL Score	0, *n* (%)	5 (50.0)	5 (50.0)	0.539 (0.344----0.845)	0.046*
	1, *n* (%)	13 (56.5)	10 (43.5)		
	2, *n* (%)	31 (68.9)	14 (31.1)		
	3, *n* (%)	30 (85.7)	5 (14.3)		