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ESWL outcomes: Analyzing key physical parameters, Wasit Province, Iraq

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Abstract
The lifetime prevalence of kidney stone illness is estimated at 1% to 15%, depending on age, gender, race, and geographic location. Calcium, a key component of almost 80% of stones, is the most prevalent component of urinary calculi.
Objectives: To study the efficacy and outcome of extra corporeal shockwave lithotripsy in the treatment of urinary stones.
Material and Methods: This is a prospective observational study performed in AL-Zahraa Teaching Hospital in 100 cases undergoing planned ESWL for renal and ureteric stones. All patients underwent laboratory investigation (including urinalysis, full blood count coagulation profile and renal function test) X-ray of kidney, ureter and bladder (KUB) for visualization of stones.
Results: A sample of 100 participants characteristics 64 males, 36 females, their age was between 17yrs-80yrs, all of them had urinary stones, their size between 4-39 mm, the most frequent sites were left and right kidneys in 32 and 26 respectively, 68 of them received 3000 shock, number of session was 1 in 46 and 2 in 37, 60 of them receive waves in frequency of 60 HZ,, about the density of stones 65 were radiopaque and 35 radiolucent.
Conclusion: A prospective observational study conducted among 100 patients with urinary stones trying to emphasize the effectivity of extra corporeal shock wave lithotripsy, which was statistically effective measure and majority of patient had positive outcome after only one session with no immediate complications or procedure failure.
Aim: The aim is study of efficiency and outcome of extracorporeal shock wave in treatment of urinary stones.

Keywords: Kidney stones, extracorporeal shock wave lithotripsy, urinary calculi, stone fragmentation, treatment outcome

1. Introduction

In medical terminology, kidney stone disease is referred to as renal calculus disease, nephrolithiasis, or urolithiasis. The Latin word "renal" means kidney, and the Greek word "nephro" means kidney. Both "calculus" (Lat.-plural calculi) and "lithiasis" (Greek) refer to stone or stones. A crystallopathy known as kidney stone disease is brought on by an excess of minerals in the urine combined with dehydration [1]. The lifetime prevalence of kidney stone disease is estimated at 1% to 15%, varying according to age, gender, race, and geographic location [2]. Stone frequency has risen from 3.8% to 8.8% over the past 30 years, according to the National Health and Nutrition Examination Survey (10.6% among men and 7.1% among women); that means the percentage of infection in males is larger than in females [2, 3]. The most common component of urinary calculi is calcium, which is a major constituent of nearly 80% of stones. Calcium oxalate comprises about 60% of all stones; mixed calcium oxalate and hydroxyapatite make up 20% and brushite stones make up 2%. Uric acid and struvite (magnesium ammonium phosphate), each comprise approximately 7% of stones, and cysteine stones represent only about 1% [4].

Numerous factors, such as the patient's age and comorbidities, the size, nature, and location of the stone, the kidney's structure, and occasionally the patient's preferences, influence the treatment choices available for renal stones [5]. Oral chemical dissolution, percutaneous nephrolithotripsy, retrograde intrarenal lithotripsy, extracorporeal shock wave lithotripsy, and open surgery are some of these alternatives [6].

Since its initial application in 1980 to treat renal stones, ESWL has been widely used to treat a wide range of urological and non-urological conditions [7].

Lithotripsy using extracorporeal shock waves using a device known as a lithotripter, a series of shock waves are produced to break up stones inside the urinary tract in a non-invasive manner. The X-ray or US is used to target the shock waves as they enter the body. Breaking the stones up into smaller bits that may be passed via the urinary tract is the aim of the operation. Although perirenal hematoma and cardiac dysrhythmias can occur in approximately 0.6% of cases, ESWL is currently the most widely used treatment modality for renal stones due to its effectiveness and relative safety [8, 9]. An imaging technique is necessary to view the stone and track its disintegration; fluoroscopy, ultrasonography, or a combination of the two are frequently employed to accomplish this [10]. The high expense of upkeep and the possibility of radiation exposure for both patients and personnel are the primary drawbacks of fluoroscopy imaging. In addition to removing the possibility of radiation exposure for both patients and personnel, ultrasonography can be used instead of fluoroscopy to locate tiny or radiolucent calculi. The lengthier learning curve and the challenge of ureteral stone localization are ultrasonography's primary drawbacks [11].

Traditional theories of stone fragmentation depend on the following: [12]

- stress gradient and tensile failure at stone/ fluid boundaries
- Acoustic cavitations
- Squeezing Compression fracture
- quasi-static squeezing wide focus with lower pressure to enhance)
- Hopkins effect (cavitation and shear forces)
- Spallation
- Dynamic fatigue
- dynamic squeezing

Materials and Methods

This is a prospective observational study performed in Al-Zahraa Teaching hospital. The number of patients that were taken are 100 patients. The main parameters were taken for study are:

1. Gender
2. Age
3. Body mass index
4. History of UTI
5. Adrenal diseases
6. GIT diseases
7. Joint diseases
8. Congenital anomalies of kidneys
9. History of lithotripsy
10. Age of stone
11. Radiological imaging of stone
12. Site, size and number of stones
13. Duration of the session
14. Type of device that used in lithotripsy
15. Number of shock waves
16. Frequency of shock wave and the complications of the ESWL

Laboratory tests, such as urinalysis, complete blood count, coagulation profile, and renal function test, as well as kidney, ureter, and bladder (KUB) ultrasound and X-rays to visualize stones, were performed on all patients. A consulting radiologist verified the size and location. As seen in figure 1, UROLITH+ ESWL PIEZOLITH 3000 was used to treat every patient.

Fig 1: ESWL Machine model (UROLITH+ ESWL PIEZOLITH 3000)

All patients were given intravenous antibiotic and intramuscular diclofenac half an hour before the procedure if they have urinary tract symptoms. After the end of sessions patients were given antibiotics and analgesics for 5 days. Patients were observed in the department of urology for one hour for any immediate complications. At 7th day KUB was done for clearance of the stone and residual fragments. Follow up was continued for next 4 week till complete clearance of the stone or failure to disintegrate. Patients were given another ESWL session if they were unable to dissolve. Two weeks separated the two sessions, and patients were instructed to seek alternative surgical treatments and were removed from the trial if no fragmentation was observed after four sessions. All patients gave their informed consent, and those who refused to repeat ESWL treatments after disintegration failed, even at the recommendation of the treating surgeon, were also not allowed to participate in the study. As outcome measures, information on the size and location of the stones was gathered and compared with the number of ESWL sessions necessary for the stones to successfully fragment. SPSS 11.5 software was used to do the statistical analysis, and Table 1 displays the results for each parameter.

Table 1: The analysis of parameters

Characteristics	Male	Female	Test	P value
Gender	64 (64%)	36 (36%)	χ^2 = 7.840	0.0051***
Ages	Minimum 35 Maximum 23 Mean ± SD 46 ± 16		T-test = 28.652	< 0.001***
Size (mm)	Minimum 4 Maximum 39 Mean ± SD 15.3 ± 6.3		T-test = 28.652	< 0.001***
Site	Rt kidney: 26 (26%) Lt kidney: 32 (32%) Rt upper ureter: 20 (20%) Lt upper ureter: 17 (17%) Rt lower ureter: 2 (2%) Lt lower ureter: 3 (3%)		χ^2 = 44.120	< 0.001***
Shock number	1000: 7 (7%) 2000: 25 (25%) 3000: 68 (68%)		χ^2 = 14.740	<

				0.001***
Number of sessions	1 session: 46 (46%) 2 sessions: 37 (37%) 3 sessions: 16 (16%) 4 sessions: 1 (1%)		$\chi^2 = 49.680$	< 0.001***
Frequency (Hz)	60: 60 (60%) 90: 29 (29%) 120: 11 (11%)		$\chi^2 = 34.940$	< 0.001***
Density	Radiolucent: 35 (35%) Radiopaque: 65 (65%)		$\chi^2 = 9.00$	0.003***

Results and Discussion

1. Gender difference: the study showed that the prevalence of stones was higher in male than females, males were 64 (64%) and females were 36 (36%), as shown in figure 2, there was statistically significant association between them (p-value = 0.005, < 0.05).

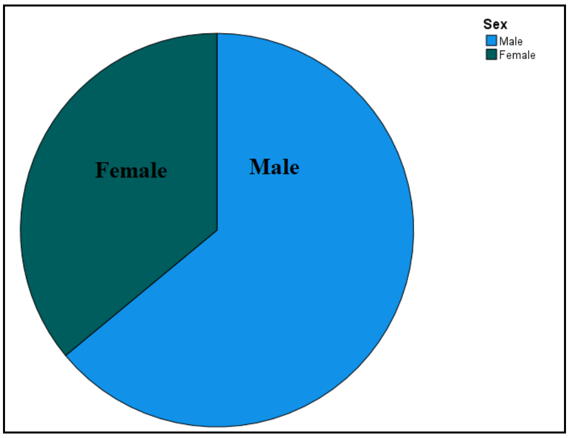

Fig 2: gender difference.

The observed gender difference in the prevalence of urinary stones, with a higher incidence in males (64%) compared to females (36%), is consistent with existing literature [4, 13]. This discrepancy can be attributed to various factors such as hormonal differences, dietary habits, and anatomical variations. The statistically significant association underscores the importance of considering gender as a potential risk factor in stone formation. These findings are consistent with another study conducted in Iraq that discovered a greater tendency to impact men than women [14].

2. Site distribution of stones: Figure 3 showed that; the left and right kidneys were the most common sites in 32 and 26 respectively, while followed by right and left upper ureters in 20 and 17 respectively and the least sites were left and right lower ureters in 3 and 2 respectively, there was statistically significant association (p value = 0.001, <0.05).

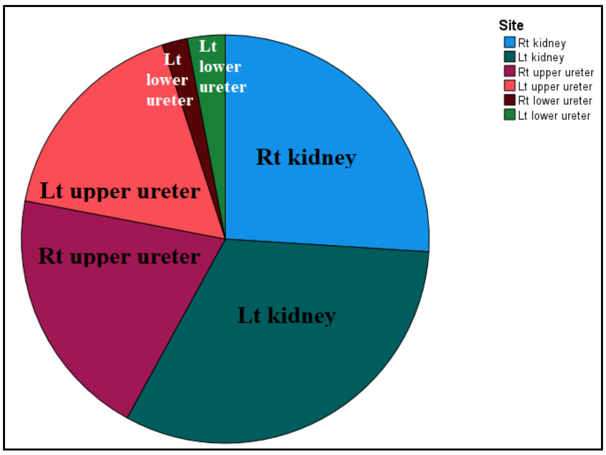

Fig 3: Site of stones

The site distribution of stones within the urinary tract is crucial for treatment planning and prognosis. The prevalence of stones in the left and right kidneys, as well as in the upper ureters, was significantly higher compared to the lower ureters. This distribution aligns with the natural progression of stone passage, where smaller stones tend to be expelled from the upper tract more easily. The significant association highlights the clinical relevance of understanding stone location when choosing treatment modalities.

Our findings are consistent with another study conducted in Iraq that discovered a propensity to include the left kidney. According to this study, the left kidney was the first anatomical location in 30% of cases, and 26% of cases had a right kidney stone. Urinary stones were more common in the other sites in a urinary system, with a tendency for numerous stones [14].

3. Difference in frequency of shocks: figure 4 showed that the majority of patients shock in frequency of 60 SW per minute (Hz) in 60%, 90 SW per minute (Hz) in 27% and 120 SW per minute (Hz) in 13%, there was statistically significant association between them (p value = 0.001, <0.05).

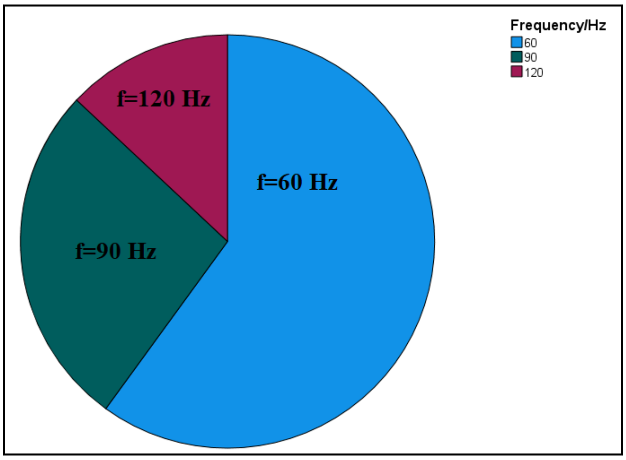

Fig 4: Frequency of shocks.

The choice of shockwave frequency is another critical parameter in ESWL. The most patients in this study received shocks at a frequency of 60 SW per minute (Hz). The association between shock frequency and treatment outcomes underscores the need for careful consideration of shockwave parameters to maximise stone fragmentation while minimising potential adverse effects.

Numerous studies were conducted. Their findings, which employed the same shock waves at rates of 60, 90, and 120 SW per minute (or known as Hz), are comparable to those of our investigation. They demonstrate that lowering the lithotripter's firing rate to 60 SW per minute or less decreases the size of kidney lesions., then followed the frequencies 90 and 120 Hz where less percentage of cases were treated in, and found the mean number of shocks required for complete stone fragmentation at the rate of 60 shocks/min was dominant and faster rates at all energy levels [15, 16].

4. Total Shock number distribution: Figure 5 showed that; the majority shocks in the period of treatment which the patients receive were about 3000 shock in 68%, 2000 in 11%, 4000 in 8%, 1000 in 7% and 2500 in 6%, there was statistically significant association between them (p value = 0.001, <0.05).

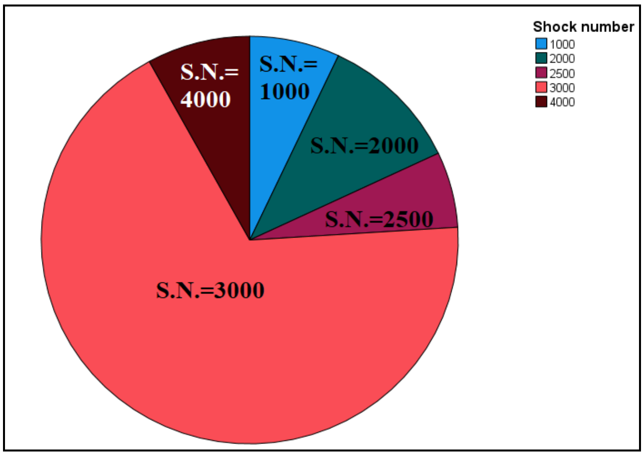

Fig 5: Total Shock number distribution

The number of shockwaves delivered during ESWL is an important parameter that can influence treatment outcomes. The majority of patients received approximately 3000 shocks. The significant association between the number of shocks and treatment outcomes emphasizes the need for individualized treatment plans based on stone characteristics and patient factors.

Generally speaking, most ESWL devices advocate using no more than about 3000 total shocks per treatment for each kidney; however, this varies depending on the equipment and whether the kidney is in the target area. More shocks can be safely administered if the kidney is left untreated because there is a lower chance of renal bruising, bleeding, contusions, hematuria, and kidney damage [17].

5. Number of sessions: figure 6 showed that; the majority of patients had one sessions in 46%, 2 in 37% while 16% had 3 sessions and 1% had 4 sessions, there was statistically significant association between them (p value = 0.001, <0.05).

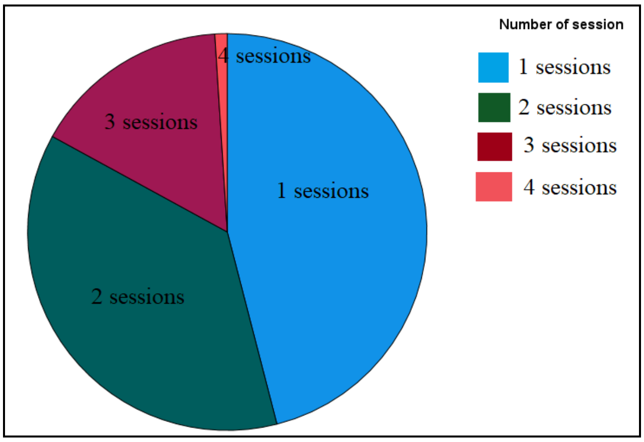

Fig 6: Number of sessions

The number of ESWL sessions required for stone fragmentation is a key consideration in patient management. A substantial percentage of patients required only one session, while others needed between two to four sessions. This information is valuable for optimising resource allocation and setting patient expectations. The significant association underscores the importance of tailoring treatment plans to individual patient needs.

The findings of the study by Jasmin Alić *et al*. were near to ours; approximately 59.1% of patients were stone-free after just one session. In contrast, 17.4% of patients required a second treatment, and 6.1% required three. An additional session was given to any that had not gone well [18].

6. Stone density: figure 7 showed that the stone 65% were radiopaque and 35% were radiolucent, there statistically significant association between them (p value = 0.003, <0.05).

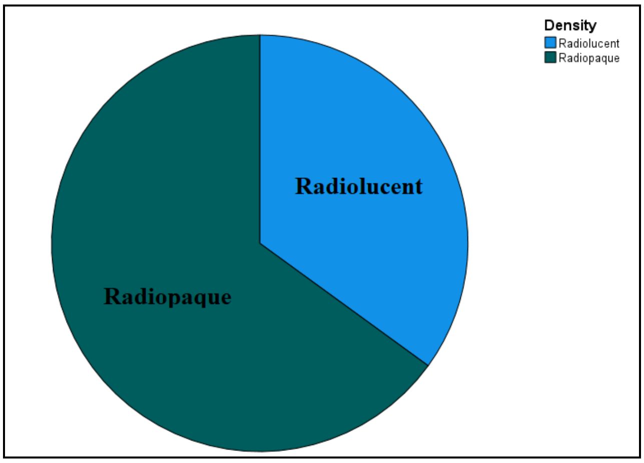

Fig 7: Stone density

Stone density plays a crucial role in determining the success of ESWL. The radiopaque stones were more prevalent (65%) than radiolucent stones (35%). This finding is consistent with the notion that radiopaque stones are generally more amenable to shockwave lithotripsy due to their ability to absorb shockwaves. The significant association between stone density and treatment outcomes reinforces the importance of preoperative stone characterization.

When making a comparison between our study and papers [19, 20], it is very clear they are compatible in results. Radiopaque, the most prevalent form of renal calculi, makes up 70% to 75% of all urinary stones. They are typically combined with calcium phosphate to make them radiopaque. Cysteine and uric acid are also present as trace amounts. Triamterene and magnesium trisilicate stones are examples of another kind of radiopaque (but not very well). The most prevalent component of bladder stones, radiolucent uric acid, comes next. It makes about 8% to 10% of urinary calculi, including those caused by ciprofloxacin, indinavir, sulphonamides, and guaifenesin/ephedrine.

Finally; this results of this study provide valuable insights into the factors that influence the efficacy and outcome of Extracorporeal Shockwave Lithotripsy in the treatment of urinary stones. These findings emphasize the importance of individualized treatment planning, taking into account gender, stone location, shockwave parameters, and stone density to optimize treatment success and patient satisfaction. Further research may be warranted to explore these factors in greater detail and refine treatment protocols for urinary stone management.

Conclusion: A prospective observational study was conducted among 100 patients with urinary stones trying to emphasize the effectivity of extracorporeal shock wave lithotripsy, which was a statistically effective measure, and the majority of patients had a positive outcome after only one session, on 3000 shock numbers, on 60 Hz frequency, with no immediate complications or procedure failure

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