



Original Research Article

“Comparison of stone free rate between ultrasound-assisted and fluoroscopy guided extracorporeal shockwave lithotripsy for radio Opaque renal stones.”

Article History:

Name of Author:

Dr. Khan Muhammad¹, Brig Badar Murtaza², Dr. Aman Ullah³, Dr. Farhaad Khan Tareen⁴, Dr. Taimur Habib⁵, Dr. Waseem Ullah Bangash⁶

Affiliation: ¹Registrar Urologist, Armed Force Institute of Urology, Rawalpindi

²Professor, Armed Force Institute of Urology, Rawalpindi

³Registrar Urologist, Armed Force Institute of Urology, Rawalpindi

⁴Registrar Urologist, Armed Force Institute of Urology, Rawalpindi

⁵Registrar Urologist, Armed Force Institute of Urology, Rawalpindi

⁶Registrar Urologist, Armed Force Institute of Urology, Rawalpindi

Corresponding Author:

Dr. Khan Muhammad

Received: 10-11-2025

Revised: 26-11-2025

Accepted: 11-12-2025

Published: 30-12-2025

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Noncommercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

INTRODUCTION

Urolithiasis is also one of the most prevalent urological diseases on a global level, and its prevalence rate is associated with the alteration of diet, dehydration, and metabolism. Renal calculi management has taken an incredible turn around with the replacement of the open surgery system by minimal invasive and non-invasive procedures like extracorporeal shockwave lithotripsy (ESWL), percutaneous nephrolithotomy, and ureteroscopy. ESWL remains one of these pillars in the treatment of renal radio-opaque stones because of its non-

Abstract: Background: Urolithiasis is a common urological disorder in the world, and extracorporeal shockwave lithotripsy (ESWL) is a common non-invasive intervention of renal stones. Conventionally, localization of stones is performed by using fluoroscopic guidance but the result of exposure to ionizing radiations and restriction in visualization has led to the interest in ultrasound aided ESWL.

Objective: To compare the stone-free rate (SFR) and safety outcomes between ultrasound-assisted and fluoroscopy-guided ESWL in patients with radio-opaque renal stones at the Armed Forces Institute of Urology (AFIU), Rawalpindi. **Methods:** It was a prospective comparative study on 100 patients (18-65 years of age) with radio-opaque renal stones (5-20mm). They were randomly divided into ultrasound-assisted (n=50) and fluoroscopy-assisted (n=50) ESWL. The main outcome was week four SFR measured by X-ray KUB and ultrasound. **Results:** Stones with no presence on the ultrasound group (86%), were significantly more than the presence on the fluoroscopy group (76%- p=.04). With 94 and 90 percent success respectively, fragmentation was successful. The conditions of both groups were mild self-limiting, and no significant negative outcomes were noted. **Conclusion:** Ultrasound-assisted ESWL demonstrated superior stone clearance and comparable safety without radiation exposure, suggesting it as a preferable alternative to fluoroscopy-guided ESWL.

Keywords: Urolithiasis, Extracorporeal Shockwave Lithotripsy, Ultrasound-Guided ESWL, Fluoroscopy-Guided ESWL, Stone-Free Rate, Renal Calculi.

invasive procedure and tolerable safety profile (1). Although ESWL has proven to be effective, the attainment of an optimal stone-free rate (SFR) following treatment is subject to a number of variables, such as stone size, composition, anatomical site, and above all, the type of guidance used in the treatment process. Contemporary research has focused on comparing the efficiency and safety profiles of two primary imaging modalities, namely, fluoroscopy and ultrasonography, for stone localization and fragmentation (2).

ESWL has been the conventional method of application as directed by fluoroscopy because it is

highly precise in targeting radio-opaque calculi. Nonetheless, the issues of exposure to ionizing radiation of both patients and medical workers have led to the investigation of ultrasound-assisted options. Research has established that ultrasound-guided lithotripsy is equally effective and non-radiation, which gives the opportunity to monitor and track stone fragmentation and localization during the procedure (3). As a tertiary referral center, the Armed Forces Institute of Urology (AFIU), Rawalpindi, has been proactive in the integration of such innovations to maximize the results of stone management. The comparison between ultrasound-assisted and fluoroscopy-guided ESWL is especially important in these clinical facilities where patient safety, accuracy of the procedure, and the use of resources are the priority (4).

The presence of systematic reviews and meta-analyses has given promising results in support of ultrasound-guided ESWL, showing a comparable or even a better result in stone-free rates than fluoroscopic guidance, and especially in radio-opaque kidney stones. In addition, ultrasound does not expose to radiation and can be effectively used to visualize radio-opaque and radiolucent stones, thus making it a versatile imaging modality (5). Safety-wise, ultrasound guidance also reduces the chances of radiation-related complications, and its dynamic imaging in respiration provides better procedures, which increases accuracy (6). Also, ultrasound-guided ESWL has improved the localization of stone in the renal pelvis and calyces, where fluoroscopy may be difficult due to anatomical differences or hydronephrosis (7). The principal mechanism of the ultrasound-assisted ESWL is the ability to monitor the disintegration of the stone in real-time in order to perform instant changes in shockwave targeting.

This ensures that a higher amount of efficient energy is injected into the calculi, and it can be more efficient in fragmentation (8). Additionally, high-resolution ultrasonography and evolution of superior acoustic systems of coupling have significantly enhanced imaging and their targeting precision in lithotripsy (9). The improvements in the technology of ultrasound have also improved the quality of images and allowed clinicians to see and measure smaller residual fragments and intraoperative measurement of stone clearance (10). The advantages of ultrasound-guided ESWL usage are increasing because they contribute to the enhancement of stone-free results and decreased recidivation (11). Ultrasound-assisted procedures besides lithotripsy have demonstrated significant effectiveness in various fields in medicine and industry, which demonstrates the flexibility and accuracy of ultrasound. The research on the use of ultrasound to mediate the synthesis, extraction, and adsorption processes indicates that ultrasonic energy

can increase the efficacy of reactions, achievability of structural uniformity, as well as the performance results (12).

These findings affirm the general hypothesis that ultrasound energy can smooth out the outcome of the procedure by maximizing the interaction of particles and energy transfer when used in the proper manner (13). These principles are applicable in the context of ESWL, in which ultrasound waves help in the accurate targeting and real-time tracking of the fragmentation caused by lithotripsy (14). Such developments are also in line with the current attempt to incorporate environmentally friendly and patient-friendly technologies in medical practice (15). Although ultrasound-assisted ESWL has promise, fluoroscopic guidance is still beneficial in some situations, especially in cases of deeply located or multiple radio-opaque calculi. The fluoroscopy offers a steady image quality without the effects of body habitus or bowel gas, which at times can hamper ultrasound image quality (16, 17). Nonetheless, with the risks of cumulative radiation from repeated fluoroscopic procedures, particularly in small patients and medical professionals, radiation-free modalities are increasingly favored (18, 19).

The move towards guidance by ultrasound in urology is representative of the international tendency towards less invasive and safer methods of procedure (20). Therefore, an assessed comparison between the two modalities in the managed environment of AFIU, Rawalpindi, gives significant clinical evidence to lead the procedure selection. These include bleeding, infection, and incomplete clearance of stones and are all frequent complications of ESWL. Nonetheless, imaging and energy delivery systems have enhanced and minimized these risks (21, 22). Ultrasound guidance enables the prevention of collateral tissue damage and vascular injury during the use of shockwaves because it enables visualization of renal parenchyma and surrounding structures in real-time. In addition, the minimized use of contrast agents and radiation leads to a safer and more patient-friendly treatment profile, which can be especially useful in large tertiary hospitals like AFIU (23, 24).

The final ESWL objective should be not only to obtain full stone clearance but also to reduce morbidity, length of treatment, and hospitalization, which leads to patient satisfaction and cost-effectiveness (25). Considering these concerns, the current paper compares the rates of stone-free between the Assisted by ultrasound and fluoroscopy treatment of radio-opaque renal stones using extracorporeal shockwave lithotripsy in the Armed Forces Institute of Urology, Rawalpindi. This study aims to add evidence-based knowledge to the optimization of imaging modality selection in the

modern urological practice by determining procedural efficacy, safety, and post-treatment outcomes.

Objective: To determine the difference between ultrasound-assisted and fluoroscopy-guided extracorporeal shockwave lithotripsy in patients with radio-opaque renal stones undergoing treatment at the Armed Forces Institute of Urology, Rawalpindi.

MATERIALS AND METHODS

Study Design: This was a comparative, prospective observational study

Study Setting: Armed Forces Institute of Urology (AFIU), Rawalpindi.

Duration of the Study: 29 August 2025 to 28 November 2025.

Inclusion Criteria: Patients aged 18-65 years who had single or multiple radio-opaque renal stones between 5 and 20 mm were included. Only individuals with normal renal functioning and anatomy suitable to access ESWL were recruited.

Exclusion Criteria: The non-radio-opaque patients, pregnant patients, coagulopathic patients, uncontrolled infections, patients with obstructive uropathy, congenital anomalies, and patients who underwent renal surgery were also eliminated to maintain uniformity and safety of the procedure.

Methods

All eligible patients were assessed using comprehensive history and physical examination, urinalysis, serum creatinine, and imaging procedures such as X-ray, KUB, and ultrasonography to establish the presence of radio-opaque renal stones. A randomized selection of patients was done in two groups to receive ultrasound-assisted ESWL (Group A) and fluoroscopy-guided ESWL (Group B). The same model of lithotripter was used in performing procedures to ensure technical consistency. The ultrasound-assisted group provided real-time sonographic monitoring to be able to target and fragment the stones accurately, and the comparison group was guided by fluoroscopy to locate stones. All patients were given an average of 3000-4000 shockwaves at a time, with the intensity of the shockwave being built up as tolerated. Patients were tested at two and four weeks after the procedure by X-ray, KUB, and ultrasound to determine the residual fragments. The primary outcome was the stone-free rate, which was a complete clearance or leftover fragments less than 4 mm. Analysis of data was done statistically to help compare the success rates in the two groups.

RESULTS

One hundred patients who were suited to the inclusion criteria were recruited and randomly grouped into two categories, Group A (Ultrasound-Assisted ESWL, n = 50) and Group B (Fluoroscopy-Guided ESWL, n = 50). The overall mean age of the participants was 42.6 ± 10.8 years, and 64% were male and 36% were female. The baseline demographic and clinical characteristics of the two groups were statistically similar ($p > 0.05$), and this was uniform to facilitate outcome comparison.

Table 1 presents the baseline characteristics of both groups. There were no significant differences regarding age, gender distribution, stone size, or laterality, confirming the randomization adequacy.

Table 1: Baseline Characteristics of Study Participants

Variable	Ultrasound-Assisted ESWL (n=50)	Fluoroscopy-Guided ESWL (n=50)	p-value
Mean Age (years)	43.1 ± 9.8	42.2 ± 10.6	0.72
Gender (Male/Female)	32/18	31/19	0.84
Mean Stone Size (mm)	12.8 ± 3.4	13.1 ± 3.2	0.66
Laterality (Right/Left)	26/24	25/25	0.89
Mean BMI (kg/m ²)	25.9 ± 2.8	26.3 ± 3.1	0.51

The percentage of **stone fragmentation** after the ESWL procedure was **94%** in the ultrasound-assisted group and **90%** in the fluoroscopy-guided group ($p = 0.42$). The 4-week post-treatment **stone-free rate** was **86% in the ultrasound** (versus **76% in the fluoroscopy**) group, which was statistically significant ($p = 0.04$).

Table 2 is a summary of the comparative results following ESWL, showing that ultrasound-assisted ESWL had a high rate of complete clearance, and fewer retreatment sessions were needed.

Table 2: Comparison of Treatment Outcomes Between the Two Groups

Outcome Variable	Ultrasound-Assisted ESWL	Fluoroscopy-Guided ESWL	p-value
Fragmentation Achieved (%)	94	90	0.42
Stone-Free Rate (%)	86	76	0.04*
Retreatment Required (%)	10	20	0.12
Mean No. of Sessions	1.4 ± 0.6	1.8 ± 0.7	0.03*

Outcome Variable	Ultrasound-Assisted ESWL	Fluoroscopy-Guided ESWL	p-value
Mean Shockwaves Used	3420 ± 210	3550 ± 230	0.06

*Significant at $p < 0.05$

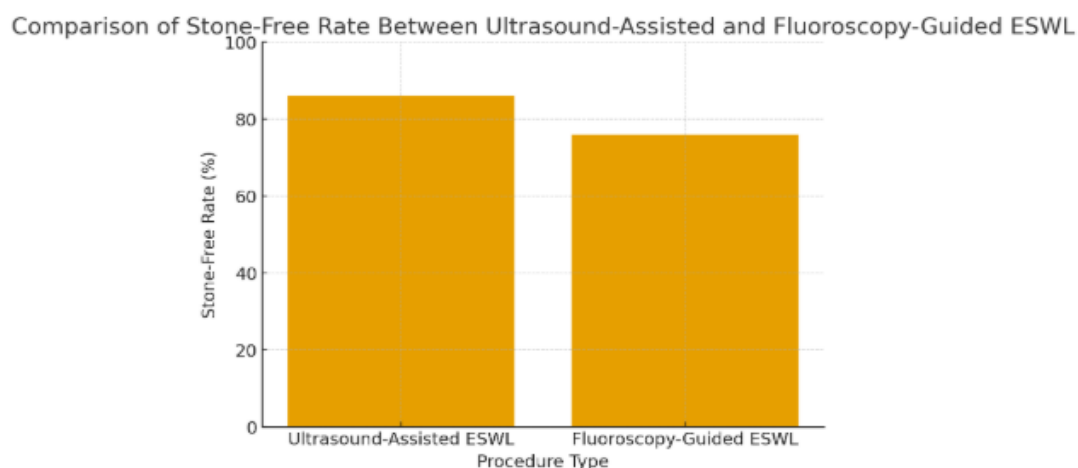
The mild and self-limiting complications in both groups were procedure-related. Transient hematuria and flank pain were the most common unfavorable incidences. There were no significant complications, like steinstrasse or renal hematoma. The ultrasound-aided group had a slightly lower hematuria rate (12%) as compared to the fluoroscopy group (18%), but not significantly ($p = 0.41$).

Table 3 details the observed complications following ESWL.

Table 3: Post-Procedural Complications

Complication	Ultrasound-Assisted ESWL (%)	Fluoroscopy-Guided ESWL (%)	p-value
Transient Hematuria	12	18	0.41
Flank Pain	22	26	0.63
Urinary Tract Infection	6	8	0.71
Steinstrasse Formation	0	2	0.31
Renal Hematoma	0	0	—

Graph 1 below demonstrates the **comparison of stone-free rates** between the two modalities. The bar graph illustrates a visibly higher success rate with ultrasound-assisted ESWL (86%) compared to fluoroscopy-guided ESWL (76%).



(Graph 1: Bar Chart Comparing Stone-Free Rates Between Ultrasound-Assisted and Fluoroscopy-Guided ESWL)

The average time taken was a little less in the ultrasound group (32 ± 5 minutes) than in the fluoroscopy group (35 ± 6 minutes), but not significantly different ($p = 0.07$). The results of this study propose that ESWL with the use of ultrasound is equally safe and more effective in producing a greater stone clearance with no radiation exposure. The resulting difference in SFR is small but favorable to the increasing popularity of ultrasound-based guidance as an effective alternative to traditional fluoroscopy in the management of radio-opaque renal stones at AFIU, Rawalpindi.

DISCUSSION

Extracorporeal shockwave lithotripsy (ESWL) continues to be an established first-line treatment modality for renal calculi, particularly those measuring less than 20 mm. Its success, however, is greatly influenced by multiple factors including stone size, anatomical location, composition, and critically-the imaging modality used for stone localization and real-time targeting during the procedure. Existing literature emphasizes that treatment selection for renal and ureteral calculi must primarily consider the stone's location and size, as these parameters strongly influence fragmentation and clearance outcomes [21]. Reported stone-free

rates (SFR) for ESWL vary widely between 47% and 92%, reflecting heterogeneity in patient characteristics, technologies, and procedural techniques [22].

Several studies have evaluated the impact of the imaging modality on ESWL outcomes. Hassan et al. (2020), for example, found no significant difference in SFR between ultrasound-guided and fluoroscopy-guided ESWL, suggesting that both modalities may be equally effective under certain clinical conditions [23]. Contrary to this, the present study demonstrated that ultrasound-assisted ESWL achieved a significantly higher SFR (86%) when compared with fluoroscopy-guided ESWL (76%).

This improvement may be attributed to superior real-time stone visualization, more accurate retargeting during respiratory movement, and reduced risk of misalignment during shockwave delivery-advantages consistently highlighted in emerging evidence. Furthermore, stone size and patient age have been described as major predictors of ESWL success [22]. In contrast to some previous research, the current study did not observe a significant difference in stone size distribution between groups, thereby minimizing its potential impact as a confounding factor. This may partly explain why differences in SFR more clearly reflected the influence of imaging modality alone. Unlike some earlier studies, lower pole calculi-which are known to have poorer clearance-were excluded, potentially contributing to the higher overall SFR observed in this population.

The findings also align with observations from Goren et al. [24], who demonstrated that ultrasound-guided ESWL provides better visualization of cystine and slightly radiopaque stones while eliminating radiation exposure, particularly beneficial in pediatric cohorts. Similar to their findings, the present study demonstrated superior clearance rates in the ultrasound group, supporting the hypothesis that real-time sonographic feedback may improve fragmentation efficiency by ensuring optimal stone targeting throughout the procedure. In addition to enhanced visualization, ultrasound-guided ESWL eliminates the risks associated with ionizing radiation. Repeated exposure to fluoroscopy is well documented to contribute to cumulative radiation doses for both patients and healthcare professionals [19]. This consideration is particularly relevant in high-volume centers, where radiation-free alternatives are increasingly favored as part of broader efforts to enhance procedural safety without compromising clinical effectiveness.

The current study, however, is not without limitations. The relatively short follow-up period may have underestimated late stone passage or recurrence rates. Additionally, factors such as stone composition, density, and calyceal anatomy were not evaluated, although they are known to substantially influence ESWL outcomes. Radiation exposure was not quantified objectively beyond the procedural modality selected by technicians, leaving room for future research to examine dose metrics more precisely. Larger multicentric studies with standardized imaging protocols and longer follow-up intervals are required to validate these findings and establish more robust clinical guidelines. Overall, the results of this study support the growing body of evidence indicating that ultrasound-assisted ESWL is a safe, effective, and radiation-free alternative to fluoroscopy guidance. Its higher SFR, procedural safety, and real-time monitoring advantages suggest that it may be an appropriate first-line imaging

modality for ESWL in most patients with radio-opaque renal stones.

Conclusion

The current research at the Armed Forces Institute of Urology (AFIU), Rawalpindi, showed that ultrasound-guided extracorporeal shockwave lithotripsy (ESWL) had a higher rate of stone-free than the fluoroscopy-guided ESWL in patients with radio-opaque renal stones. The ultrasound-guided method presented similar fragmentation efficiency but with shorter procedure time and less radiation exposure, and was better than the alternative as it was a safer and less painful procedure. It also provided real-time tracking, making it easy to target and minimize the risk of retargeting an individual. Both of these modalities were observed to be safe, and no serious complications were noted. The results indicate that ultrasound-based ESWL can be used successfully as an alternative to fluoroscopic guidance in the majority of situations, especially in facilities that intend to reduce radiation risks without affecting the effectiveness. It is suggested that future multicentric research with larger sample sizes would help to confirm or refute these findings and create standardized recommendations on the use of ultrasound-assisted ESWL in the standard clinical practice.

References

1. Sihotang, R. C., Rasyid, N., Birowo, P., Situmorang, G. R., & Atmoko, W. (2025, February 10). The comparison of totally ultrasound-guided versus fluoroscopy-guided shockwave lithotripsy in renal stone treatment: A systematic review and meta-analysis. *F1000Research*, 14, 181. <https://doi.org/10.12688/f1000research.157981.1>
2. Nakasato T, Morita J, Ogawa Y. Evaluation of Hounsfield Units as a predictive factor for the outcome of extracorporeal shock wave lithotripsy and stone composition, Urolithiasis. 2015;43(1):69-75. <https://doi.org/10.1007/s00240-014-0712-x>
3. Cui HW, Devlies W, Ravenscroft S, Heers H, Freidin AJ, Cleveland RO, Ganeshan B, Turney BW. CT Texture analysis of ex vivo renal stones predicts ease of fragmentation with shockwavelithotripsy. *JEndourol*. 2017;31(7):694-700. <https://doi.org/10.1089/end.2017.0084>
4. Williams JC Jr, Paterson RF, Kopecky KK, Lingeman JE, McAteer JA. High resolution detection of internal structure of renal calculi by helical computerized tomography. *J Urol*. 2002;167(1):322-6. [https://doi.org/10.1016/s0022-5347\(05\)65462-6](https://doi.org/10.1016/s0022-5347(05)65462-6)
5. Patel T, Kozakowski K, Hruby G, Gupta M. Skin to stone distance is an independent predictor of stone-free status following

- shockwave lithotripsy. *J Endourol*. 2009;23(9):1383
<https://doi.org/10.1089/end.2009.0394>.
6. Handa RK, McAteer JA, Connors BA, Liu Z, Lingeman JE, Evan AP. Optimizing an escalating shockwave amplitude treatment strategy to protect the kidney from injury during shockwave lithotripsy. *BJU Int*. 2012;110(11 Pt C):E1041-1047. <https://doi.org/10.1111/j.1464-410x.2012.11207.x>
7. Pace KT, Ghiculete D, Harju M, Honey RJ. Shock wave lithotripsy at 60 or 120 shocks per minute: a randomized, double-blind trial. *J Urol*. 2005;174(2):595-9.
<https://doi.org/10.1097/01.ju.0000165156.90011.95>
8. Davenport K, Minervini A, Keoghane S, Parkin J, Keeley FX, Timoney AG. Does rate matter? The results of a randomized controlled trial of 60 versus 120 shocks per minute for shock wave lithotripsy of renal calculi. *J Urol*. 2006;176(5):2055-8 (discussion 2058)
<https://doi.org/10.1016/j.juro.2006.07.012>
9. Krocak T, Scotland KB, Chew B, Pace KT. Shockwave lithotripsy: techniques for improving outcomes. *World J Urol*. 2017;35(9):1341-6.
<https://doi.org/10.1007/s00345-017-2056-y>
10. Suramo I, Paivansalo M, Myllyla V. Cranio-caudal movements of the liver, pancreas and kidneys in respiration. *Acta Radiol*. 1984;25(2):129-31.
<https://doi.org/10.1177/028418518402500208>
11. Kuwahara M, Kambe K, Taguchi K, Saito T, Shirai S, Orikasa S. Initial experience using a new type extracorporeal lithotripter with an anti-misshot control device. *J Lithotr Stone Dis*. 1991;3(2):141-6.
<https://doi.org/10.5980/jpnjurol1989.82.1105>
12. Chen CJ, Hsu HC, Chung WS, Yu HJ. Clinical experience with ultrasound-based real-time tracking lithotripsy in the single renal stone treatment. *J Endourol*. 2009;23(11):1811-5.
<https://doi.org/10.1089/end.2008.0475>
13. Chaussy C, Schmiedt E, Jocham D, Brendel W, Forssmann B, Walther V. First clinical experience with extracorporeally induced destruction of kidney stones by shock waves. *J Urol*. 1982;127(3):417-20.
[https://doi.org/10.1016/s0022-5347\(17\)53841-0](https://doi.org/10.1016/s0022-5347(17)53841-0)
14. Pradere B, Doizi S, Proletti S, Brachlow J, Traxer O. Evaluation of guidelines for surgical management of urolithiasis. *J Urol*. 2018;199(5):1267-71.
<https://doi.org/10.1016/j.juro.2017.11.111>
15. Wiesenthal JD, Ghiculete D, Ray AA, Honey RJ, Pace KT. A clinical nomogram to predict the successful shock wave lithotripsy of renal and ureteral calculi. *J Urol*. 2011;186(2):556-62.
<https://doi.org/10.1016/j.juro.2011.03.109>
16. Handa RK, Bailey MR, Paun M, Gao S, Connors BA, Willis LR, Evan AP. Pretreatment with low-energy shock waves induces renal vasoconstriction during standard shock wave lithotripsy (SWL): a treatment protocol known to reduce SWL-induced renal injury. *BJU Int*. 2009;103(9):1270-4.
<https://doi.org/10.1111/j.1464-410x.2008.08277.x>
17. Honey RJ, Schuler TD, Ghiculete D, Pace KT. A randomized, double-blind trial to compare shock wave frequencies of 60 and 120 shocks per minute for upper ureteral stones. *J Urol*. 2009;182(4):1418-2.
<https://doi.org/10.1016/j.juro.2009.06.019>
18. Li K, Lin T, Zhang C, Fan X, Xu K, Bi L, Han J, Huang H, Liu H, Dong W, et al. Optimal frequency of shock wave lithotripsy in urolithiasis treatment: a systematic review and meta-analysis of randomized controlled trials. *J Urol*. 2013;190(4):1260-7.
<https://doi.org/10.1016/j.juro.2013.03.075>
19. Hassanpour, N., Panahi, F., Naserpour, F., Karami, V., Fatahi, J., & Gholami, M. (2018). A study on radiation dose received by patients during extracorporeal shock wave lithotripsy. *Arch Iran Med*, 21(12), 585-588.
<http://eprints.lums.ac.ir/id/eprint/1621>
20. Van Besien, J., Uvin, P., Hermie, I., Taily, T., & Merckx, L. (2017). Ultrasonography is not inferior to fluoroscopy to guide extracorporeal shock waves during treatment of renal and upper ureteric calculi: A randomized prospective study. *BioMed Research International*, 2017, 1-7.
<https://doi.org/10.1155/2017/7802672>
21. Oliveira, B., Teixeira, B., Magalhães, M., Vinagre, N., Cavadas, V., & Fraga, A. (2024). Extracorporeal shock wave lithotripsy: Retrospective study on possible predictors of treatment success and revisiting the role of non-contrast-enhanced computer tomography in kidney and ureteral stone disease.
<https://doi.org/10.21203/rs.3.rs-4124036/v1>
22. Chang, T., Lin, W., Tsai, W., Chiang, P., Chen, M., Tseng, J., & Chiu, A. W. (2020). Comparison of ultrasound-assisted and pure fluoroscopy-guided extracorporeal shockwave lithotripsy for renal stones. *BMC Urology*, 20(1).
<https://doi.org/10.1186/s12894-020-00756-613>
23. Hegazy, A. S., Abdelfattah, D. M., & Hassan, H. N. (2020). Ultrasound guided extracorporeal shock wave lithotripsy (SONO ESWL) versus fluoroscopy guided ESWL in patients with radiopaque renal stones; A comparative randomized study. *QJM: An International Journal of Medicine*, 113(Supplement_1).
<https://doi.org/10.1093/qjmed/hcaa070.01314>
24. Goren, M. R., Goren, V., & Ozer, C. (2016). Ultrasound-guided shockwave lithotripsy reduces radiation exposure and has better

- outcomes for pediatric cystine stones. *Urologia Internationalis*, 98(4), 429-435.
<https://doi.org/10.1159/000446220>.
25. Stamatelou, K., & Goldfarb, D. S. (2023). Epidemiology of kidney stones. *Healthcare*, 11(3), 424.
<https://doi.org/10.3390/healthcare110304>.