Cerrahpaşa Med J 2024; 48(3): 284-288 ORIGINAL ARTICLE

Shock Wave Lithotripsy in Anomalous Kidneys: An Experience of a Tertiary Care Institution

Muhammed Fatih Şimşekoğlu[1], Berin Selçuk[1], Uğur Aferin[2], Ahmet Gürbüz[1], Engin Dereköylü[1], Sinharib Citgez[1], Çetin Demirdağ[1], Bülent Önal[1]

[1]Department of Urology, İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, İstanbul, Türkiye
[2]Department of Urology, Demiroğlu Bilim University, School of Medicine, İstanbul, Türkiye

Cite this article as: Şimşekoğlu MF, Selçuk B, Aferin U, et al. Shock wave lithotripsy in anomalous kidneys: an experience of a tertiary care institution. *Cerrahpaşa Med J.* 2024;48(3):284-288.

Abstract

Objective: The treatment of stones in anomalous kidneys requires challenging approaches. This study aimed to determine the factors affecting shock wave lithotripsy (SWL) results for stones in anomalous kidneys.

Methods: We retrospectively analyzed patients with anomalous kidneys who underwent SWL for kidney stones between January 1993 and December 2019. Patients were divided into 2 groups (stone-free group, group 1, and failure group, group 2). Demographic and clinical parameters were assessed. The predictors of stone-free status following SWL were identified.

Results: There were 67 male (72.2%) and 29 female (27.8%) patients, and the median age was 40 (30-49) years. Of the 96 patients, 42 (43.8%) had horseshoe kidneys, 37 (38.5%) had duplex systems, 12 (12.5%) had renal parenchymal anomalies (polycystic kidney and medullary sponge kidney), and 5 (5.2%) had ectopic pelvic kidneys. Stone clearance was achieved in 53 (55.2%) of the 96 patients. The median stone volume was 1.2 (0.7-1.6) cm^2 in group 1 and 1 (0.6-3) cm^2 in group 2 (P = .796). In terms of complications (P = .982) and stone-free status (P = .587), there were no statistically significant differences between the different types of anomalies. However, recurrent stones were found to have lower stone-free rates than new-onset stones (P = .029).

Conclusion: In this study, only recurrent stones were found to have lower stone-free rates. SWL has similar effectiveness for different anomaly types.

Keywords: Anomalous kidney, kidney stone, SWL, lithotripsy

Introduction

Congenital renal anomalies occur in different spectra with respect to structural and functional characteristics. The incidence of renal anomalies varies according to the type of anomaly.[1] In horseshoe kidneys, the most common type of renal anomaly per live birth (1/400), the incidence of kidney stones can reach 20-60%.[2] The presence of renal anomalies increases the risk of developing kidney stones.[3] The risk of stone formation in congenital renal anomalies increases with poor urine flow and stasis. In polycystic kidney disease and other parenchymal disorders, stone development is associated with metabolic and hereditary factors.[4]

The treatment of stones in anomalous kidneys is challenging. Therefore, different treatment options should be considered when making treatment decisions for optimal disease management. In addition to percutaneous nephrolithotomy (PCNL) and ureterorenoscopy (URS), significant progress has been made in shock wave lithotripsy (SWL) techniques, especially in terms of stone targeting and energy transfer. Although there is limited literature on the use of SWL in anomalous kidneys, SWL may be a suitable treatment method in selected patient groups.[5] In this study, we aimed to provide single-center knowledge about SWL using second and third-generation lithotripters in anomalous kidneys.

Received: June 21, 2024 **Revision Requested:** September 26, 2024
Last Revision Received: October 24, 2024 **Accepted:** November 12, 2024
Publication Date: December 18, 2024
Corresponding author: Muhammed Fatih Şimşekoğlu, İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, İstanbul, Türkiye.
e-mail: m.fatihsimsekoglu@gmail.com
DOI: 10.5152/cjm.2024.24025

Methods

The İstanbul University-Cerrahpaşa Review Board approved the study (Approval no: 21263603-604.02.01-153794, Date: November 19, 2019). Between January 1993 and December 2019, 3859 patients who underwent SWL by a single urologist (N.T.) for kidney stones were evaluated. The data of 96 (2.48%) patients with renal anomalies were identified. An anomalous kidney was identified by computed tomography (CT), intravenous pyelography (IVP), or CT urography (CTU).

Demographic (age, gender, body mass index) data, clinic data (medical history, previous treatment, stone side, stone volume, stone localization, stone number), and treatment outcomes (type of lithotripters, session number, shock wave number, mean maximum energy, stone clearance, steinstrasse, complications) were retrieved from the medical records. Stone volume was measured as the 2 maximal diameters of single stones or the sum of the diameters of multiple stones.

Shock wave lithotripsy procedures were performed using second-generation (Lithostar®, Siemens Medical Solutions, Inc.) and third-generation (Lithoskop®, Siemens Medical Systems, Erlangen, Germany) electromagnetic lithotripters. The development of the lithotripter by improving the localization system and shock wave energy in the transition from the second-generation lithotripter to the third-generation lithotripter has opened the possibility of successful fragmentation of stones. Shock wave lithotripsy was performed after eliminating urinary infections. The procedures were performed under general anesthesia in only 1 (2%) patient. Shock wave lithotripsy was performed while the patient was supine. An SWL session was usually started with 60 shock waves/min, and the number of shock waves was increased to 100 waves/min. There were 3-7-day intervals between SWL sessions.

Treatment results, such as stone-free status and complications, were analyzed using clinical and radiologic (CT, IVP, USG) data at the time of the visit performed 1 month after the end of the planned SWL protocol. Patients with no residual calculus and those with a stone volume of <0.4 cm^2 in the presence of residual calculi were stone-free (group 1) within the first 3 sessions. Patients with a residual stone volume of >0.4 mm^2 were included in the failure group (group 2).[6]

The data were stored in an Excel® database, and the Statistical Package for Social Sciences version 23.0 software (IBM Corp.; Armonk, NY, USA) was used for the analysis. Different patient, stone, and treatment outcomes were assessed according to stone-free status using logistic regression, Chi-square, Fisher exact and Mann–Whitney *U* tests. Statistical significance was accepted as a *P* value of <.05.

Results

The study included 67 male (72.2%) and 29 female (27.8%) patients, and the median age was 40 (30-49) years. Of the 96 patients, 42 (43.8%) had horseshoe kidneys, 37 (38.5%) had duplex systems, 12 (12.5%) had renal parenchymal anomalies (polycystic kidney and medullary sponge kidney), and 5 (5.2%) had ectopic pelvic kidneys. These 5 patients with ectopic pelvic kidneys had health problems that included a high risk for anesthesia. Shock wave lithotripsy was performed due to the risk of anesthesia. Two patients in group 2 had chronic renal failure. No complications were observed after SWL.

All stones were radiopaque. The stones were on the left side in 53 (55.2%) patients and 43 (44.8%) were on the right side. While 41 (42.7%) of the patients had multiple stones, 55 (57.3%) had a single stone. Before SWL, 10 (10.4%) patients required a double J catheter, and 2 (2.1%) required a nephrostomy tube. Table 1 shows the other clinical and demographic data before SWL.

The median stone volume was 1.2 (0.7-1.6) cm^2 in group 1 and 1 (0.6-3) cm^2 in group 2 (P = .796). Stone clearance was achieved in 53 (55.2%) of the 96 patients. Although the highest stone-free rate was observed in the renal parenchymal anomaly group (66.6%) and the lowest stone-free rate was observed in the horseshoe kidney group (42.6%), the differences between the anomaly type and stone-free rate were not statistically significant (P = .117). However, recurrent stones (40.5%) were found to have a lower stone-free rate than new-onset stones (64.4%) (***P* = .022**).

In group 1, 5 of 53 (9.4%) patients had complications (urinary tract infection, acute urinary obstruction, and mild hematuria), and in group 2, 4 (9.3%) patients developed complications (P = .982). There were no major complications in group 1. However, 1 of 4

Table 1. Characteristics of Patients and Stones

	Group 1 (n = 53)	Group 2 (n = 43)	Total (n = 96)	*P*
Age, (years), median (IQR)	40 (26-48)	41 (33-51)	40 (30-49)	.320+
Gender, n (%)				
Male	38 (71.7)	29 (67.4)	67 (72.2)	.652
Female	15 (28.3)	14 (32.6)	29 (27.8)	
Anomaly, n (%)				.587*
Horseshoe kidney	20 (37.7)	22 (51.2)	42 (43.8)	
Pelvic ectopy	3 (5.7)	2 (4.7)	5 (5.2)	
Duplex collecting system	22 (41.5)	15 (34.9)	37 (38.5)	
Renal parenchymal anomaly	8 (15.1)	4 (9.3)	12 (12.5)	
Stone side, n (%)				
Right	24 (45.3)	19 (55.8)	43 (44.8)	.914*
Left	29 (54.7)	24 (44.2)	53 (55.2)	
Stone site, n (%)				
Pelvis	28 (52.8)	16 (37.2)	44 (45.8)	.118*
Upper calyx	8 (15.1)	6 (14)	14 (14.6)	
Middle calyx	4 (7.5)	1 (2.3)	5 (5.2)	
Lower calyx	13 (24.5)	20 (46.5)	33 (34.4)	
Stone volume (cm^2), median (IQR)	1.2 (0.7-1.6)	1 (0.6-3)	1.1 (0.3-1.1)	.796+
Classified stone volume (mm^2), n (%)				
1-10	23 (43.4)	22 (51.2)	45 (46.9)	.257*
11-20	23 (43.4)	12 (27.9)	35 (36.5)	
> 20	7 (13.2)	9 (20.9)	16 (16.7)	
Stone number, n (%)				
Single	30 (56.6)	25 (58.1)	55 (57.3)	.880*
Multiple	23 (43.4)	18 (41.9)	41 (42.7)	
Stone nature, n (%)				
New onset	38 (71.7)	21 (48.8)	59 (61.5)	**.022***
Recurrent	15 (28.3)	22 (51.2)	37 (38.5)	

IQR, interquartile range.

Table 2. Treatment Outcomes of Patients Treated with SWL

	Group 1 (n = 53)	Group 2 (n = 43)	Total (n = 96)	P
Lithotripter type, n (%)				.778*
Second generation	40 (75.5)	31 (72.1)	71 (73.9)	
Third generation	13 (24.5)	12 (17.9)	25 (26.1)	
Auxiliary procedures (pre-SWL), n (%)				.059*
Double J	2 (3.8)	8 (18.6)	10 (10.4)	
Nephrostomy	1 (1.9)	1 (2.3)	2 (2.1)	
None	50 (94.3)	34 (79.1)	84 (87.5)	
Session number, median (IQR)	2 (1-3)	3 (2-4)	2 (1-3.7)	.054+
Sock wave number, median (IQR)	2000 (1700-2500)	2000 (1750-2700)	2000 (1700-2529)	.213+
Maximum energy, (kV) median (IQR)	17.3 (16.9-18.1)	17.2 (17.1-46.2)	17.2 (17.1-18.3)	.536+
Complications, n (%)				
Yes	5 (9.4)	4 (9.3)	9 (9.4)	
No	48 (90.6)	39 (90.7)	87 (90.6)	.982*

*Chi square, +Mann–Whitney *U*.
IQR, interquartile range; SWL, shock wave lithotripsy.

patients in group 2 presented with subcapsular hematoma. This patient did not require any intervention and was treated conservatively. Data including other clinical findings and treatment results are summarized in Table 2. Multivariate analysis was performed to identify independent factors affecting the stone-free rate. On multivariate analysis, only recurrent stones were independently associated with the stone-free rate after SWL (***P* = .029**) (Table 3). In group 1, recurrence was observed in 9 patients (60%) after endoscopic treatment and in 6 patients (40%) after SWL. In group 2, recurrence was observed in 16 (72.7%) patients after endoscopic treatment and in 6 (27.3%) patients after SWL.

Discussion

In this study, only recurrent stones were found to have lower stone-free rates. No other preoperative or postoperative factors independently affected the stone-free rate of kidney stones treated with SWL in anomalous kidneys. It was concluded that SWL has similar effectiveness for different anomaly types.

Table 3. Multivariate Analysis of Parameters in Patients Treated with SWL

	95% C.I. for EXP. (B)		
Variables	**Lower**	**Upper**	***P***
Age, (years)	0.964	1.016	.454♠
Stone side, (right/left)	0.354	2.085	.737♠
Stone nature, (new onset/recurrent)	1.283	3.093	**.029**♠
Anomaly type	0.109	1.954	.293♠
Stone localization	0.262	3.599	.966♠
Session number	0.619	1.060	.125♠
Sock wave number	0.999	1.000	.348♠
Maximum energy	0.989	1.007	.695♠

♠Anova Test.
CI, confidence interval.

Shock wave lithotripsy has maintained its clinical value since 1980, when it was initially applied to treat kidney stones, as it is the only noninvasive method.[7] As a result of technological developments, advances have been observed in kidney stone treatment with the introduction of lithotripters with high stone targeting and fragmentation efficiency.[8] Studies have reported that SWL is preferred for treating stones in anomalous kidneys in selected patients despite the serious anatomical and functional limitations associated with stone treatment.[5] However, data about stone-free rates and complications of kidney stones treated with SWL in patients with anomalous kidneys are limited.

When renal anomalies are considered, the occurrence of stones is much higher than in the normal population.[9] Therefore, increasing SWL success is important for reducing stone-related morbidity. The stone-free rate of SWL in anomalous kidneys ranges from 54% to 82%.[5] Tunc et al[10] reported a stone-free rate of 50% in patients with lower calyceal stones. However, it was shown in the same study that middle calyceal stones had higher success rates (60%). In our study, the overall stone-free rate was 55.2%. Although stone-free rates vary widely in the literature, the stone-free rate was relatively low in our study. This result can be explained by the high percentage of lower calyx-located stones in group 2 (34.4%).

In the literature, some factors may affect the stone-free rates of SWL. The clinical, metabolic, and anatomical changes that may be seen depending on patient characteristics, stone characteristics, type of anomaly, and other conditions accompanying the anomaly may be attributed to the differences observed in stone-free rates.[11,12] Among these factors, anatomical features and stone size were most emphasized. There is a consensus in the literature that stone size directly affects the stone-free rate in SWL treatment.[6,11,13] Some studies have shown that stone size is also associated with steinstrasse and obstruction after SWL.[14] However, in our study, there were no significant differences in stone size between group 1 and group 2. The underlying reason for this finding may be the low overall stone-free rates in the 2 groups with abnormal kidneys.

Recurrent stones are a challenging condition for treating kidney stones. It is important to identify and treat the underlying cause of stone recurrence to prevent further occurrences. However, recurrent stones are not uncommon. Studies in the literature have reported that stone history may affect SWL success.[15] Recurrent stones are also stones that are resistant to treatment. In our study, SWL was less successful in treating recurrent stones, which is consistent with the literature.

There are different results in the literature regarding the effect of the anomaly type on the stone-free rate. Although some studies emphasize that there is no significant difference in stone-free rates due to the type of anomaly, there are also studies reporting reduced stone-free rates in horseshoe and polycystic kidneys compared to duplex collecting systems and ectopic kidneys.[11,16,17] In our study, although the highest stone-free rate was observed in the renal parenchymal anomaly group and the lowest stone-free rate was observed in the horseshoe kidney anomaly group, the differences between the anomaly type and stone-free rate were not statistically significant. It is thought that this result may be related to the presence of other factors that may affect the stone-free rate and the small sample size.

In studies comparing stone-free rates obtained with different lithotripters, it was concluded that the type of lithotripter did not affect the success rate, as our study.[11,18] A multi-center study with more than 1800 patients by Bierkens et al[18] reported no difference in stone-free rates in patients who underwent SWL with 5 different lithotripters. However, all lithotripters compared in this study were second-generation devices, and patients did not have an anomalous kidney. It was concluded that there was no statistically significant difference in second and third-generation lithotripter rates between group 1 and group 2 ($P = .778$). These results are in accordance with the literature.

Studies revealing differences in the complication rates in anomalous kidneys are limited. The overall complication rates associated with SWL obtained from different studies were found to be 5-7%, and it was emphasized that there was no significant increase in complication rates in the presence of kidney anomalies.[19,20] In our study, the overall complication rate was 9.4%. These rates are nearly double those reported for non-anomalous kidneys in the literature. Thus, our study highlights the importance of close follow-up for stones in anomalous kidneys.

We acknowledge the limitations of the current study. The study was conducted using a retrospective design in a single center with a small study group. In addition, other variables that may affect the stone-free rate, such as stone type, stone Hounsfield unit (HU), and the anatomical structure of the calyx were not considered.

Conclusion

In this study, only recurrent stones were found to have lower stone-free rates. No other preoperative or postoperative factors independently affected the stone-free rate of kidney stones treated with SWL in anomalous kidneys. It was concluded that SWL has similar effectiveness for different anomaly types.

Availability of Data and Materials: The data that support the findings of this study are openly available.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of the İstanbul University-Cerrahpaşa (Approval no: 21263603-604.02.01-153794, Date: November 19, 2019).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Acknowledgment: We acknowledge Nejat Tansu for his efforts in performing SWL.

Author Contributions: Concept – M.F.S., B.Ö.; Design – Ç.D.; Supervision – B.Ö.; Resources – S.Ç.; Materials – E.D.; Data Collection and/or Processing – A.G.; Analysis and/or Interpretation – B.S.; Literature Search – U.A.; Writing Manuscript – M.F.S.; Critical Review – Ç.D.; Other – U.A.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

References

1. Tain YL, Luh H, Lin CY, Hsu CN. Incidence and risks of congenital anomalies of kidney and urinary tract in newborns: a population-based case-control study in Taiwan. *Med (Baltim)*. 2016;95(5):e2659. [CrossRef]
2. Ishii H, Rai B, Traxer O, Kata SG, Somani BK. Outcome of ureteroscopy for stone disease in patients with horseshoe kidney: review of world literature. *Urol Ann*. 2015;7(4):470-474. [CrossRef]
3. Pawar AS, Thongprayoon C, Cheungpasitporn W, Sakhuja A, Mao MA, Erickson SB. Incidence and characteristics of kidney stones in patients with horseshoe kidney: a systematic review and meta-analysis. *Urol Ann*. 2018;10(1):87-93. [CrossRef]
4. Nobakht N, Hanna RM, Al-Baghdadi M, et al. Advances in autosomal dominant polycystic kidney disease: a clinical review. *Kidney Med*. 2020;2(2):196-208. [CrossRef]
5. Wani M, Mohamed AHA, Brown G, Sriprasad S, Madaan S. Challenges and options for management of stones in anomalous kidneys: a review of current literature. *Ther Adv Urol*. 2023;15(15):17562872231217797. [CrossRef]
6. Faddan AA, Najieb O, Gadelkareem RA. Predictors of stone-free rate after a single-session extracorporeal shockwave lithotripsy for a single kidney stone measuring 10 to 20 mm: a private center experience. *Curr Urol*. 2023;17(1):30-35. [CrossRef]
7. Malinaric R, Mantica G, Martini M, et al. The lifetime history of the first Italian public extra-corporeal shock wave lithotripsy (ESWL) lithotripter as a mirror of the evolution of endourology over the last decade. *Int J Environ Res Public Health*. 2023;20(5):20(5):4127. [CrossRef]
8. Lingeman JE, McAteer JA, Gnessin E, Evan AP. Shock wave lithotripsy: advances in technology and technique. *Nat Rev Urol*. 2009;6(12):660-670. [CrossRef]
9. Raj GV, Auge BK, Assimos D, Preminger GM. Metabolic abnormalities associated with renal calculi in patients with horseshoe kidneys. *J Endourol*. 2004;18(2):157-161. [CrossRef]
10. Tunc L, Tokgoz H, Tan MO, Kupeli B, Karaoglan U, Bozkirli I. Stones in anomalous kidneys: results of treatment by shock wave lithotripsy in 150 patients. *Int J Urol*. 2004;11(10):831-836. [CrossRef]
11. Sheir KZ, Madbouly K, Elsobky E, Abdelkhalek M. Extracorporeal shock wave lithotripsy in anomalous kidneys: 11-year experience with two second-generation lithotripters. *Urology*. 2003;62(1):10-5; discussion 15. [CrossRef]
12. Azal Neto W, Reis LO, Pedro RN. Prediction of stone-free rates following extracorporeal shockwave lithotripsy in a contemporary cohort of patients with stone densities exceeding 1000 HU. *Scand J Urol*. 2020;54(4):344-348. [CrossRef]
13. Rajaian S, Kumar S, Gopalakrishnan G, Chacko NK, Devasia A, Kekre NS. Outcome of shock wave lithotripsy as monotherapy for large solitary renal stones (>2 cm in size) without stenting. *Indian J Urol*. 2010;26(3):359-363. [CrossRef]
14. Phukan C, Nirmal TJ, Wann CV, et al. Can we predict the need for intervention in steinstrasse following shock wave lithotripsy? *Urol Ann*. 2017;9(1):51-54. [CrossRef]
15. Gültekin MH, Türegün FA, Ozkan B, et al. Does previous open renal stone surgery affect the outcome of extracorporeal shockwave lithotripsy treatment in adults with renal stones? *J Endourol*. 2017;31(12):1295-1300. [CrossRef]
16. Demirkesen O, Yaycıoglu O, Onal B, et al. Extracorporeal shockwave lithotripsy for stones in abnormal urinary tracts: analysis of results and comparison with normal urinary tracts. *J Endourol*. 2001;15(7):681-685. [CrossRef]
17. Ganpule AP, Desai MR. Urolithiasis in kidneys with abnormal lie, rotation or form. *Curr Opin Urol*. 2011;21(2):145-153. [CrossRef]

18. Bierkens AF, Hendrikx AJM, de Kort VJ, et al. Efficacy of second-generation lithotripters: a multicenter comparative study of 2206 extracorporeal shock wave lithotripsy treatments with Siemens lithostar, Dornier HM4, Wolf piezo- lith 2300, Dirextripter X1 and Breakstone lithotripters. *J Urol*. 1992;148(3 Pt 2):1052-6; discussion 1056. [CrossRef]
19. Sighinolfi MC, Sandri M, Eissa A, et al. The safety of extracorporeal shock wave lithotripsy: an undervalued issue. *Int Urol Nephrol*. 2019;51(3):457. [CrossRef]
20. Yucel S, Akin Y, Danisman A, Guntekin E. Complications and associated factors of pediatric extracorporeal shock wave lithotripsy. *J Urol*. 2012;187(5):1812-1816. [CrossRef]