

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

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Abstract

Background: Despite the continuous update of guidelines for the management of kidney stones, the ability to predict a successful response to extracorporeal shockwave lithotripsy (SWL) remains a topic of research. This is due to the need to refine the decision making in the context of technological advancements and current pandemics. This study aimed to determine the predictors of stone-free rate (SFR) after single-session SWL in adult patients with a single kidney stone 10 to 20 mm in diameter.

Materials and methods: A retrospective review of the records of patients with a single kidney stone 10 to 20 mm in diameter was performed at a private SWL center from December 2019 to February 2021. Univariate and multivariate analyses were performed for stone- and patient-related factors, using the Student *t* and Mann-Whitney *U* tests for the quantitative variables and the Fisher exact and Pearson correlation tests for the qualitative variables.

Results: A total of 138 patients were eligible for this study, including 92 men and 46 women. The mean age was 38.6 ± 12.4 years, and the mean body mass index (BMI) was 25.9 ± 3.4 kg/m². Four weeks after SWL, 120 patients (87%) were free of stones, and 18 (13%) needed further treatment. Univariate analyses showed that SFR was negatively correlated with increased BMI ($p = 0.0001$), maximum stone length ($p = 0.0001$), transverse diameter of the stone ($p = 0.0001$), number of shocks per session ($p = 0.052$), and Hounsfield unit (HU) ($p = 0.0001$). Multivariate analysis revealed that HU ($p = 0.009$), maximum stone length ($p = 0.01$), BMI ($p = 0.000$), and presence of double-J stent ($p = 0.034$) were independent risk factors for failure of single-session SWL in the treatment of kidney stones 10 to 20 mm in diameter. The estimated average cost per case was USD 450.5.

Conclusions: Increased HU, maximum stone length, BMI, and presence of double-J stents were independent risk factors for low SFR after single-session SWL for a kidney stone 10 to 20 mm in diameter. The cost of SWL remains an advantage in the private sector.

Keywords: Kidney stone; Lithotripsy; Medium-sized stones; Shockwave lithotripsy; Stone-free rate

1. Introduction

Extracorporeal shockwave lithotripsy (SWL) is a well-established treatment option for small and medium kidney stones, with variable published success rates reaching up to 90%.^[1-4] This variation is attributed to general and specific independent predictors. The former includes differences in clinical settings and inconsistencies in the proposed clinical outcome measures of treatment success. However, the latter includes variability in size, density, intrarenal location, and skin-to-stone distance (SSD) on noncontrast computed tomography (NCCT).^[1,3,5] The size of kidney stones is the main predictor of their treatment. For a size less than 10 mm, SWL is still offered as the first treatment option.^[2,3] However, for a size of 10 to 20 mm, further

competitive options such as percutaneous nephrolithotomy (PNL) and retrograde intrarenal surgery (RIRS) can be offered.^[6] Regarding the intrarenal location of stones, SWL results in less successful outcomes in managing lower pole stones due to unfavorable factors for SWL, such as the calyceal anatomy. Therefore, it is offered as a second-line treatment relative to the increase in stone size.^[6,7]

Advances in endourology armamentarium may play a cardinal role in SWL losing ground in the management of kidney stones to other modalities with published higher stone-free rates (SFRs) than SWL.^[6,8,9] However, the cost-effectiveness of SWL versus that of other modalities has favored SWL as the cheapest treatment option, regardless of the size of stones amenable to SWL.^[2,10,11] On the contrary, there is a clear inverse relationship between the size of kidney stones and the effectiveness of SWL. Moreover, clear cutoff values have been published in guidelines for recommending SWL for treating different sizes of stones.^[2,12,13] However, the criterion standard option for medium stones has not been defined yet.^[13,14] Thus, research trials are being conducted to study different modalities of treatment. This study aimed to refine the evidence for decision making in the context of the evolving demands of increasing populations, technological advancements, and the current coronavirus disease 2019 (COVID-19) pandemic.^[2,3,9,11,14,15] Therefore, the ability to identify which stone cases will respond successfully to SWL remains a point of research that represents the backbone of our rationale for conducting this retrospective study.

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2. Materials and methods

From December 2019 to February 2021, 186 patients underwent SWL to treat kidney stones 10 to 20 mm in diameter at a private SWL center managed by the authors. This study included adult patients older than 18 years with a single kidney stone 10 to 20 mm in the largest diameter. Twenty-two patients younger than 18 years and 26 patients who had multiple stones were excluded. All patients were evaluated by history taking and physical examinations. Demographic data, including age, sex, and body mass index (BMI), were reviewed. In addition, the preoperative medical history of previous renal surgery or recent double-J stent (JJ) insertion into the target kidney was reviewed. Investigations included urine analysis, coagulation profile, plain kidney-ureter-bladder (KUB) radiography, and NCCT before treatment. The KUB was performed to determine whether the stones were radiopaque or radiolucent. Data on stone laterality, location, longitudinal and transverse axes, Hounsfield units (HU), and presence of JJ stent were obtained from NCCT reports. Hounsfield units were estimated using magnified bone windows, and the mean of multiple small regions of interest was measured in the 2 largest dimensions.^[16]

On an outpatient basis, each patient was administered intravenous fluids (normal saline or Ringer’s solution) and analgesia immediately before the SWL session. The SWL procedure was performed using a lithotripter with a biplane fluoroscopy C-arm and ultrasound unit (Novalith NT-10, Novamedtek, Turkey). It uses the electrohydraulic shockwave generation technology. Considering the predefined opacity nature of the stone in the preoperative KUB, stone localization was performed by either fluoroscopy C-arm (X-ray) or ultrasound. Based on pain tolerance, the session was performed with further analgesia or intravenous sedation coverage. We implemented a ramping SWL technique with 2500 to 3000 shocks per session and a frequency of 1.0 to 1.5 Hz (60–90 shocks/minute). Each session started at a power of 60 (12 kV) for the first 500 shocks, followed by 1000 to 1500 shocks at a power of 80 (16 kV), and the remaining 500 to 1000 shocks were delivered at a power of 90 (18 kV).^[11] On-demand analgesia, an α -blocker agent, and a small daily dose of diuretics were prescribed to all patients as a postoperative medical expulsive treatment for 4 weeks.

Four weeks after the first SWL session, the scheduled routine follow-up included urinalysis, abdominal ultrasonography, and KUB (for radiopaque stones). Noncontrast computed tomography was requested for patients to confirm the stone-free status (SFS) or successful SWL when ultrasonography was inconclusive to detect the absence of stones or residual stones of 4 mm or less. The SFS was the primary outcome, defined as the status in which complete disintegration and absence of the stone were diagnosed or the presence of remaining clinically insignificant residual fragments of 4 mm or less after a single SWL session. The remaining fragments greater than 4 mm in size warranted another session, which was considered an auxiliary treatment.

In the present study, the costs were estimated considering the differences in governmental prices.^[11] The primary single-session costs US \$185. The costs of additional services and treatment of complications were estimated.

This study was approved by our local ethics committee (institutional review board no. 17300592/2021). Informed consent was waived off, because of the retrospective nature of the study.

The data were analyzed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as the mean \pm standard deviation and range. Categorical variables were presented as the number and percentage of each category. Student *t* test was used to compare continuous

variables, and Fisher exact test was used for categorical variables. Quantitative variables with a significant effect on success rates according to the univariate analysis were further analyzed using the Mann-Whitney *U* test. Pearson correlation tests were used to determine the correlation between patients, renal and stone variables, and the SFR. A 2-tailed *p* value less than 0.05 was considered to indicate statistical significance.

3. Results

A total of 138 patients (92 men and 46 women) were eligible for this study. The mean \pm standard deviation age was 38.6 \pm 12.4 years, and the mean BMI was 25.9 \pm 3.4 kg/m². Patient and stones characteristics are shown in Table 1.

Shock wave lithotripsy was performed in the presence of JJ in 17 patients (12.3%). The indications for JJ were the presence of a solitary or better functioning kidney in 7 patients (41.2%), previous ureteroscopy in 6 patients (35.3%) with concomitant ureteral and kidney stones in 5 patients or migrated ureteral stones in 1 patient, and residual stones after PNL in 2 patients (11.8%) or open surgery in 2 patients (11.8%).

Table 1
Patient and stone characteristics.

Variable	Values
Age, mean \pm SD (range), yr	38.6 \pm 12.4 (19–70)
Sex, n (%)	
Male	92 (66.7)
Female	46 (33.3)
Side, n (%)	
Right	81 (58.7)
Left	57 (41.3)
Stone density in X-ray	
Radiopaque	117 (84.8)
Radiolucent	21 (15.2)
Site, n (%)	
UPJ	39 (28.3)
Pelvis	66 (47.8)
Upper calyx	5 (3.6)
Middle calyx	12 (8.7)
Lower calyx	16 (11.6)
Previous kidney surgery, n (%)	
Fresh (no open surgery)	128 (92.8)
Recurrent	10 (7.2)
Double-J stent, n (%)	
Yes	17 (12.3)
No	121 (87.7)
Sedation, n (%)	
Yes	50 (36.2)
No	88 (63.8)
BMI, mean \pm SD (range), kg/m ²	25.9 \pm 3.4 (19–31.2)
BMI grades, n (%)	
Normal	81 (58.7)
Overweight	54 (39.1)
Obese	3 (2.2)
HU, mean \pm SD	1093.7 \pm 392.5 (132–1693)
HU categories, n (%)	
\leq 1000 HU	50 (36.2)
>1000 HU	88 (63.8)
Maximum length of the stone, mean \pm SD (range), mm	15.6 \pm 5 (5.9–25)
Transverse diameter of the stone, mean \pm SD (range), mm	10.8 \pm 3.9 (3–22)

BMI = body mass index; HU = Hounsfield unit; SD = standard deviation; UPJ = ureteropelvic junction.

Upon reaching SFS 4 weeks after SWL, the patients were divided into 2 groups. The SWL success group included 120 patients (87%), representing the SFR. However, the SWL failure group with residual stones greater than 4mm included only 18 patients (13%) who needed further SWL sessions. Of these, 9 patients (50%) were cleared after the second session, including 2 patients (22.2%) with stones at the pelviureteral junction and 7 patients (77.8%) with stones in the renal pelvis. However, 3 patients (16.7%) were cleared after the third session, including 2 patients (66.7%) with stones in the renal pelvis and 1 patient (33.3%) with a stone in the middle calyx. The other 6 (33.3%) patients had sessions of SWL, but only 2 (33.3%) of them with stones in the middle calyx were cleared, and the remaining 4 patients (66.7%) were referred for PNL because of minimal or absent response after the last 2 sessions. The latter 4 patients included 3 patients (75%) with stones in the lower calyx and 1 patient (25%) with a renal pelvic stone.

According to the univariate analyses (Tables 2–4), SFR was not significantly correlated with any of the qualitative factors analyzed by Fisher exact test or the quantitative variables analyzed by Student *t* test (Tables 2, 3). However, analysis of the quantitative variables using the Mann-Whitney *U* test showed that SFR was negatively correlated with increases in BMI, maximum stone length, transverse diameter of stone, and HU (for all, *p* = 0.0001) (Table 4).

In the multivariate analysis, we tested stone-, patient-, and kidney-related factors. The HU (*p* = 0.009) and the maximum

Table 2
Univariate analysis of the qualitative factors that predict SWL success at 4 weeks (Fisher exact test).

Variable	Success group, n (%)	Failure group, n (%)	<i>p</i>
Total number	120 (87)	18 (13)	
Sex			0.542
Male	75 (62.5)	6 (33.3)	
Female	45 (37.5)	12 (66.7)	
Side			0.039
Right	84 (70)	11 (61.1)	
Left	53 (30)	7 (38.9)	
Stone density in X-ray			0.542
Radiopaque	102 (85)	15 (83.3)	
Radiolucent	18 (15)	3 (16.7)	
Stone site			0.616
UPJ	37 (30.8)	2 (11.1)	
Pelvis	56 (46.7)	10 (55.6)	
Upper calyx	5 (4.2)	0	
Middle calyx	9 (7.5)	3 (16.7)	
Lower calyx	13 (10.8)	3 (16.7)	
Double-J stent			0.011
Yes	11 (9.2)	6 (33.3)	
No	109 (90.8)	12 (66.7)	
Sedation			0.301
Yes	45 (37.5)	5 (27.8)	
No	75 (62.5)	13 (72.2)	
BMI			0.0001
Normal	80 (66.7)	1 (5.6)	
Overweight	39 (32.5)	15 (83.3)	
Obese	1 (0.8)	2 (11.1)	
HU			0.0001
≤1000 HU	50 (41.7)	0	
>1000 HU	70 (58.3)	18 (100)	
Stone size, mm			0.0001
≤15	72 (60)	1 (5.6)	
>15	48 (40)	17 (94.4)	

BMI = body mass index; HU = Hounsfield units; SWL = shockwave lithotripsy; UPJ = ureteropelvic junction.

Table 3
Univariate analysis for quantitative continuous variables that predict SWL success at 4 weeks (Student *t* test).

Variable	Success, Mean ± SD	Failure, Mean ± SD	<i>p</i>
Age, yr	38.3 ± 12.5	40.4 ± 12.2	0.881
BMI, kg/m ²	24.1 ± 2.4	27.7 ± 1.5	0.025
No. shocks	1580.8 ± 386.7	2794.4 ± 467.1	0.500
Maximum length of the stone, mm	14.8 ± 4.8	20.9 ± 3.1	0.040
Transverse diameter of stone, mm	10.3 ± 3.7	14.6 ± 3.3	0.722
HU	1045.8 ± 348.1	1412.6 ± 170.5	0.003

BMI = body mass index; HU = Hounsfield units; SD = standard deviation; SWL = shockwave lithotripsy.

length of the stone (*p* = 0.010) as stone-related factors, and BMI (*p* = 0.000) and presence of JJ (*p* = 0.034) were independent risk factors for failure to reach SFS after a single-session SWL for the treatment of kidney stones 10 to 20 mm in diameter (Table 5).

Complications included renal colic in 27 patients (19.6%), fever in 11 patients (8%), and subcapsular hematoma in 4 patients (2.9%). No steinstrasse or persistent hematuria (continued for >3 days) was diagnosed during follow-up. Among these cases, which were managed conservatively, only two with persistent renal colic and fever were treated with JJ placement.

The average cost per case was estimated to be USD 450.5. This cost includes all costs of the main and additional services (Table 6).

4. Discussion

Medium kidney stones have been variably defined as stone measuring between 10 and 30 mm. Most studies have defined them as stones measuring 10 to 20 mm.^[2,4,7,8,14–17] However, many other studies have adopted different values, such as 10 to 25 mm,^[18] 15 to 25 mm,^[19] and 20 to 30 mm,^[10,11] in which SWL is mostly incorporated as a treatment option. This may imply that this size spectrum is the most confusing on the scale of stone size relative to the numerous available treatment options, such as SWL, PNL, RIRS, and their varieties and combinations.^[1,3,14,17] This confusion revealed a continuous need to refine the decision-making process in the context of rapid changes and advances in the field of endourology.^[3,9] The current series of patients with a stone size of 10 to 20 mm examined a specific point of refining the predictors

Table 4
Univariate analysis of the quantitative variables that predict SWL success at 4 weeks (Mann-Whitney *U* test).

Variable	SFR	Median, range, interquartile range	Median rank	<i>p</i>
HU	Yes	1106, 1561, 510	63.68	0.0001
	No	1417.5, 555, 332	108.3	
Maximum length of the stone, mm	Yes	13.9, 19, 6.9	63.2	0.0001
	No	21.5, 12, 4.3	111.5	
Transverse diameter of the stone, mm	Yes	9.75, 19, 5.3	64.01	0.0001
	No	14, 11, 5.3	106	
BMI, kg/m ²	Yes	23.9, 12, 3.4	62.52	0.0001
	No	27.7, 5.5, 2.4	116	
No. shocks	Yes	2600, 2700, 700	66.97	0.052
	No	2900, 2000, 500	86.39	

BMI = body mass index; HU = Hounsfield units; SFR = stone-free rate; SWL = shockwave lithotripsy.

Table 5
Multivariate analysis (logistic regression analysis) for variables predicting SWL success at 4 weeks.

Variables	B	SE	Wald	95% CI	p
Stone-related variables					
HU	0.004	0.001	6.867	1.001–1.007	0.009
Maximum length of the stone, mm	0.267	0.103	6.678	1.067–1.599	0.010
Transverse diameter of the stone, mm	-0.025	0.116	0.045	0.777–1.225	0.832
Stone location	0.036	0.177	0.042	0.733–1.466	0.838
Patient- and kidney-related variables					
BMI, kg/m ²	0.696	0.164	17.990	1.454–2.766	0.000
Presence of JJ	-1.52	0.719	4.478	0.053–0.894	0.034
Previous kidney surgery	-0.113	1.319	0.007	0.067–11.863	0.932

B = binary regression; CI = confidence interval; HU = Hounsfield units; SE = standard error; SWL = shockwave lithotripsy; BMI = body mass index; JJ = double-J stent.

of SWL success, which was the SFR after a single-session SWL, similar to other studies.^[3,5] However, in most studies, predictors of SWL success have usually been evaluated relative to the overall SFR.^[7,11,12] These predictors have been classically classified into patient-, stone-, kidney-, and technique-related factors.^[1,2]

Patient-related factors that are associated with a decreased probability of SWL success include increasing age of the patient, BMI, SSD, and female sex.^[1,2] By contrast, Shinde et al.^[12] reported that female sex and the presence of JJ are the only independent risk factors for SWL failure. This finding could be attributed to the inclusion of ureteral stones in their study and different definitions of

SWL success. Furthermore, the use of JJ with SWL was found to be nonbeneficial for stone clearance.^[20,21] Our results showed that the presence of JJ was an independent risk factor for the failure of SWL, which is concordant with the previously mentioned findings.

Stone-related factors include stone density (HU), stone diameter and volume, number of stones, stone heterogeneity, and stone location.^[1] Skin-to-stone distance with stone density and dimension or volume is the components of a predictive model for the response to SWL, known as the Triple-D score.^[2,5] Sengupta et al.^[5] evaluated the applicability of the Triple-D score in predicting SFR after a single-session SWL for stones measuring 10 to 20 mm. They found a parallel increase in SFR with an increase in the total score value, proving the validity of this model as an independent predictor.^[5] Although we did not implement this model because of the retrospective pattern of the data, which was not available for certain items, our results showed significant differences in SFR relative to the stone size, largest diameter, and HU. Many other studies have reported similar outcomes for these factors for predicting SFR after SWL.^[1,2] Cumulatively, our results support these well-known findings in the literature. Moreover, as data were obtained from a private center, they may provide scientific evidence to extrapolate these well-known findings from the academic and governmental sectors to the private sector.

The mean HU values on NCCT are commonly used to predict stone response to SWL. Although there is no definitive cutoff value, measures of 900 to 1000 HU have been used to differentiate between high and low stone hardness and SWL success.^[2,11] Because of the nonhomogenous stone densities, a further parameter named the heterogeneity index has been studied. Hence, radiological heterogeneity of stones has been reported as an independent predictor of SWL success.^[2]

Table 6
Distribution, summation, and average costs of SWL services at 4 weeks (n = 138).

Service category	Service item	Price of service item*, USD	No. patients who received the service (total frequency of service) [†]	Summation of costs of each service, USD
Primary procedure	SWL	185	138 (138)	25,530
Auxiliary procedure	SWL	100	18 (27)	2700
	JJ placement	260	2 (2)	520
	PNL	1000	4 (4)	4000
Follow-up imaging	At 2wk			
	US	15	138 (148)	2220
At 4wk	KUB	15	117 (117)	1755
	US	15	138 (138)	2070
	KUB	15	87 (87)	1305
	NCCT	65	26 (26)	1690
Follow-up laboratory tests	CBC	15	43 (14)	210
	Urinalysis	10	138 (125)	1250
Admission for emergency	Medications	200	19 (31)	6200
	Medical fees	250	4 (4)	1000
Medication course at home		40	138 (176)	7040
Transportation		10	138 (192)	1920
Others (communications, prints, cards, etc)		20	138 (138)	2760
Total services costs, USD				62,170
Average costs per patient, USD				450.5

*The costs of the primary and auxiliary SWL procedures were provided as total packages. This includes the costs of the main intervention and associated services. For primary SWL, the costs (US \$185) could be empirically distributed into the following: costs of the SWL machine (US \$90), medical personnel fees (US \$40), medications (US \$30), disposables (US \$20), and registration files (US \$5). The other services were performed outside these packages in terms of average costs. Considering that the primary treatment could be achieved by the primary procedure, the costs of the primary SWL procedure were higher than those of the auxiliary procedures.

[†]Frequency of the service is not usually equal to the number of patients who received this service because of repeating the service for auxiliary treatment; follow-up of stone clearance; or other nonscheduled medical, imaging, or laboratory services.

CBC = complete blood count; JJ = double-J stent; KUB = kidney-ureter-bladder radiography; NCCT = noncontrast computed tomography; PNL = percutaneous nephrolithotomy; SWL = shockwave lithotripsy; US = ultrasonography; USD = US dollars.

The lower pole location has an unfavorable characteristic relative to its effect on the SFR after SWL. In these cases, various predictors should be considered when defining the optimal treatment modality, including stone size, patient body habitus, and spatial calyceal anatomy.^[6,7] Relative to these predictors, RIRS has evolved as the best treatment option for lower pole stones 10 to 20 mm with better SFR and lower kidney damage than SWL. However, it is also associated with disadvantages, such as the risk of ureteral injuries, the need for high expertise, and the costs of complex endourological instruments. When these disadvantages are considered, there would have been a limited diffusion of this procedure in developing countries. Hence, SWL may still have some priorities in the treatment of kidney stones.^[7] In concordance, the current results showed comparable SFRs between all stone locations. Specifically, large proportions of middle and lower calyceal stones were cleared after a single-session SWL. This may support offering SWL for lower-pole stones, especially in the absence or limited availability of minimally invasive facilities. However, other factors such as stone size and density should be also considered, as discussed previously.^[6,7]

Technical factors such as frequency of shock waves, energy levels, accuracy of targeting the stone, focus size, and patient breathing patterns also affect the efficacy of SWL.^[1,2] Stepwise ramping techniques of SWL have been reported to reduce the risk of SWL-induced perirenal hematomas while maintaining excellent outcomes.^[3,22,23] Similarly, we implemented a ramping or a slow progressive voltage technique in the treatment of the current series with a high SFR (87%). Although this SFR is higher than those in many other studies,^[1] it is still within the reported range of SFR in the literature.^[2] This finding may indicate that SWL in private centers provides excellent outcomes that are comparable with those of governmental centers. However, we propose that the possibility of selecting cases managed in private centers may be an underlying reason for this high SFR. Another proposal is that the lower number of patients treated in private centers in the context of better availability of resources may allow the proper presentation of services, including scheduling, implementation, and revision of the cases. This outcome may provide a basis for escalating the role of the private sector of health facilities in withstanding a part of the load of urolithiasis management during the current COVID-19 pandemic. In our country, the cost of SWL has been reported to be significantly lower than that of PNL, even for large stones. In addition, they may still be lower after the addition of the costs of the auxiliary procedures and other associated services.^[11] As the current study targeted stone sizes of 10 to 20 mm after a single-session SWL, costs would imperatively be lower than those of the other treatment options.

The advantages of the study include examining SFR after a single session of SWL in a series of patients with stones 10 to 20 mm. The current results may help in encouraging the decision making of directing patients with stones similar to be referred for SWL, thereby avoiding the risks of invasive interventions and anesthesia during the current COVID-19 pandemic.^[2] Moreover, by presenting this experience of a private SWL center, this study may be the first to propose the important role of the private health sector in our country during the current pandemic, in the context of these excellent outcomes. Thus, further national and international comparative studies of the proposed positive effect of private SWL centers during this pandemic are highly recommended.

The limitations of the study were mainly related to the retrospective nature of this case series. First, missing data were included on certain predictors of SWL, such as SSD and the anatomical characteristics

of the pelvicalyceal system. Second, we were unable to implement a controlled or comparative study design. Third, the relatively small sample size may limit the generalizability, but it could be correlated with the relatively lower number of patients treated in the private sector. Finally, the generalizability of the proposed advantageous role of private SWL centers in the management of the COVID-19 pandemic may be limited because of the single-center nature of the study.

5. Conclusions

Single-session SWL provides a high SFR with a low complication profile and low cost for kidney stones 10 to 20 mm. Stone-free rate was negatively correlated with increased BMI, maximum stone length, transverse diameter of stones, HU, number of shocks per session, and the presence of JJ. Of these factors, high maximum stone length, HU, and the presence of JJ were independent risk factors for low SFRs. The cost of SWL in private centers seems comparable with those in government centers.

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Statement of ethics

This study was approved by the local institutional review board (IRB: 17300592/2021). Written informed consent was waived because of the retrospective nature of the study. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflict of interest statement

The authors declare no conflicts of interest.

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Author contributions

AAF participated in concept design, practical work, data collection, statistical analysis, writing, revision, and approval. He declares no conflicts of interest. ON participated in practical work, data collection, writing, revision, and approval. He declares no conflicts of interest. RAG participated in concept design, statistical analysis, writing, revision, supervision, and approval. He declares no conflicts of interest.

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