UROLOGY

Original Research

Factors influencing extracorporeal shockwave lithotripsy efficiency in the management of lower pole stones

Dóra-Andrea Miheler[1], Tibor Reman[2], Raul Gherasim[2], Olivér Á. Vida[2], Daniel Porav-Hodade[2], Orsolya Mártha[2]

1) Department of Obstetrics and Gynecology, Clinical County Emergency Hospital Mures, Targu Mures, Romania

2) Department of Urology, George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu Mures, Romania

DOI: 10.15386/mpr-2913

Manuscript received: 01.07.2025
Received in revised form: 22.07.2025
Accepted: 22.08.2025

Address for correspondence:
Tibor Reman
reman_tibi@yahoo.com

Abstract

Objectives. The low efficacy of extracorporeal shock wave lithotripsy (ESWL) in the treatment of lower pole stones is well known; the parameters which influence this effect are still under debate: patient age, stone size, presence of double J stent, body mass index (BMI), and radiological parameters of the lower calyx, such as infundibulopelvic angle (IPA), infundibulum length (IL), and width (IW) of patients and the skin-stone size.

Methods. We studied the effectiveness of extracorporeal shock wave lithotripsy (ESWL) in the treatment of lower calyx stones. All patients were investigated by uro-CT or intravenous urography (IVU), or kidney, ureter, bladder (KUB) radiography to confirm the diagnosis. J stents were inserted before therapy in 64 (18.6%) renal units. Factors affecting success, stone-free rate and complications were analyzed. We measured the skin-stone distance (SSD) of the lower calyx on 39 uro-CT image data, and infundibulum length, width and infundibulopelvic angle on 31 intravenous urography (IVU).

Results. Our retrospective study (between 2021 and 2024) included a total of 344 patients who underwent ESWL for lower calyceal stone (172 men, 172 women) with an average stone size 9.093±2.829 mm. 68.605% of patients became stone-free after the first ESWL session. The average skin stone distances measured in 0°, 45°, 90° angles were 96.5 ± 24.92 mm. Using the Chi-square test, we concluded that previously stented patients had a statistically lower stone-free rate (SFR) than those without a stent. (p=0.0078). The body mass index (BMI) of patients also influenced the SFR, as calculated with an Unpaired t-test and Welch correction (p = 0.002). We did not find any statistically significant differences between skin-stone sizes of patients with or without successful stone fragmentation (p=0.1147), and infundibulum length (p=0.07), infundibulum width (p=0.7681), and infundibulopelvic angle (p=0.996).

Conclusions. Single ESWL sessions often fail to achieve stone fragmentation and elimination, as this study shows. The success of ESWL sessions can be affected by the anatomical position of the stone, a lower pole kidney stone, the presence of pre-procedural double J stenting, and obesity.

Keywords: extracorporeal shockwave lithotripsy, lower pole stone, double J stent, urolithiasis

Introduction

Approximately 35% of renal calculi are lower pole kidney stones (LPS) [1]. There is considerable debate regarding the management of these stones, as the anti-gravitational position of the lower calyx can cause not just urinary stasis and stone formation but it can lead to more difficult stone elimination [2,3]. Current treatment options include medical expulsive therapy, extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS), percutaneous nephrolithotomy (PCNL), and laparotomy [4].

ESWL is not just advantageous for being minimally invasive, but fragmentation sessions are shorter than any other modalities [5,6]. Additionally, ESWL sessions can be easily repeated with low complication rates. On the other hand flexible ureteroscope (higher than 270 degrees deflection and with smaller scope size) have shown a rather high success rate in treating LPS [7], leading to a quicker stone-free status than ESWL [8]. PCNL remains the appropriate treatment option for LPS larger than 2 cm, or when the patients have a long infundibulum or a narrow infundibulopelvic angle [9].

What significant factors might influence the low stone-free rate of ESWL in treating LPS? The ongoing discussion concerns the following parameters: stone size, presence of double J stent, age, body mass index (BMI), and anatomical/radiological parameters of the lower calyx, such as infundibulopelvic angle (IPA), infundibulum length (IL), and width (IW) of patients [10–12].

Methods

Our retrospective study analyzed 353 patients with lower calyx stones treated with ESWL, using Siemens Lithostar with fluoroscopic monitoring, in our Department of Urology, Târgu Mureș, between January 2021 and July 2024. Eligible patients were at least 18 years old, all of them with lower calyx calculi.Inclusion criteria were single, radiopaque stone located originally in the lower calyx, of not more than 20 mm in its greatest diameter (based on EAU Guideline); stones of different compositions were allowed, patients who underwent previous surgery, open or endourologic, and those with recurrent calculi, or patients requiring stenting for various reasons. Patients with associated renal congenital malformations we excluded. Patients were divided into two groups: group 1 without a double-J stent (280 patients) and group 2 with a stent (64 cases-18.6%). All the patients had a plain abdominal X-ray, 39 of them a pre-procedural abdominal CT, and 31 patients a pre-procedural intravenous urography.

Patients were prepared according to routine hospital procedures, there was no anaesthesia, except in case of significant discomfort. An immediate post-procedural plain film was taken.

The success of stone fragmentation was checked after ESWL using ultrasonography and plain abdominal X-ray in a one-month time window for the success of fragment passage. Treatment was considered successful if the patient was stone-free or had a stone fragment of less than 4 mm. (definition of failed ESWL: a failure is that case in which a satisfactorily fragmented stone fails to clear in 6 months follow-up [13].

We studied, using the online imaging database Pixel the following parameters: skin-stone distance (SSD), the lower pole infundibulopelvic angle (IPA) using the method of El-Bahnasy et al., the infundibular length (IL) and width (IW).

We used GraphPad Prism 8.4.3 for the statistical analysis, the t-student test and Mann Whitney test for quantitative parameters, and the chi-square method for the binary qualitative data to calculate the correlation between age, gender, body mass index, and the stone-free rate after ESWL. A p-value less than 0.05 indicated statistical significance.

Results

From the total of 353 patients with lower pole calculi treated by ESWL, 344 patients met the inclusion criteria, nine of them being excluded because of the coexisting kidney congenital malformation (horseshoe kidney, renal and ureteral duplication).

The baseline demographic of the study group is presented in table I, male and female genders were equally represented. There were more left lower pole kidney stones (53.48%) than right ones (46.52%) (Figure 1). Figure 2 presents the patients' age.

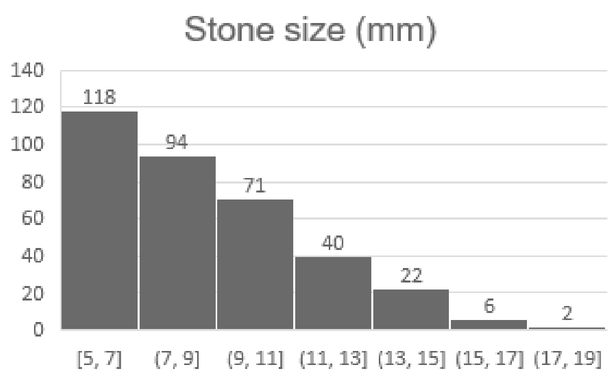

Figure 1. Stone size of the lower pole calculi.

Table I. Demographic, clinical, and technical ESWL data of the study population.
Regarding stone size, the smallest lower pole stone was 5 mm, and the maximal stone size was 19 mm.
Regarding the chemical composition, there were mostly Ca-oxalate (Table I).

Total nr. of patients	353 (344-included)
Excluded patients (urinary tract malformation)	9
Gender	F: 172 (50%) M: 172 (50%)
Stone position	Right: 160 (46.52%) Left: 184 (53.48%)
Double J-stent	64 (18.6%)
SFR	68.605%
Avr. stone size (mm)	9.093± 2.829
Avr. age of patients (years)	50.85±13.36
Avr. BMI (kg/m2)	27.17±4.451
Number of shock wave	Minimal:1500 Maximal: 3000
Energy level	Maximal: 3.2
Length of stay (LOS) (days)	1.631±1.836
Chemical composition	calcium oxalate dihydrate 95.67%, calcium oxalate monohydrate 3.47%, uric acid 0.86%

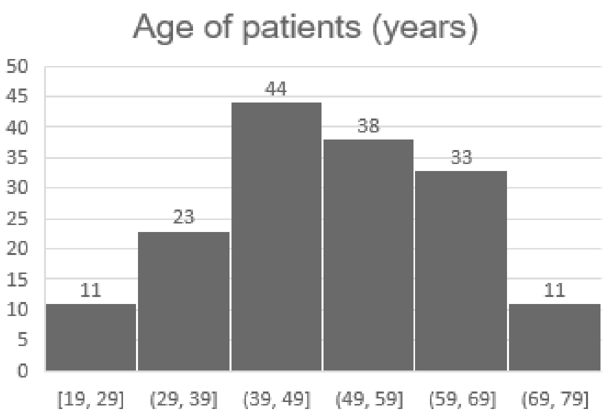

Figure 2. Age of the patients treated with ESWL for lower pole calculi.

We analyzed the parameters of 39 NCCT (Table III) and 31 intravenous urography (Table IV). The average skin-stone distance at 0° was 97.450 mm, at 45°, 96.9 mm and at 90° 94.842 mm. We made an arithmetic average of the SSD in each grade mentioned before, which was 94.732 mm. We had more left lower pole stones between patients with intravenous urography. We measured infundibular length, width, and infundibulopelvic angle; the average IL was 24.801 mm, IW was 3.886 mm and IPA was 64.673°. We analyzed possible factors influencing stone size, age, localization of stone, sex of patients, presence of double J stent, body mass index (BMI), skin-stone distance (SSD), infundibulum length (IL), infundibulum width (IW), infundibulo-pelvic angle (IPA) (Tables II and III.) We concluded using the Chi-square test that previously stented patients (gr.2) had a statistically significantly lower success rate (SFR) than those without a stent (gr.1).

Table II. Parameters measured on non-contrast CT (NCCT).

Nr. of CT	39, SFR (38.46 %)
Avr. SSD at 0° (mm)	97.450 mm
Avr. SSD at 45° (mm)	96.909 mm
Avr. SSD at 90° (mm)	94.842 mm
Avr. SSD (mm)	94.732 mm
Nr. of the right lower pole stone	16
Nr. of left lower pole stone	23

Table III. Parameters measured on intravenous urography (IVU).

Nr. of intravenous urography (IVU)	31
Nr. of the right lower pole stone	11
Nr. of left lower pole stone	20
Average infundibulum length (IL) (mm)	24.801
Average infundibulum width (IW) (mm)	3.886
Average infundibulopelvic angle (degrees)	64.673

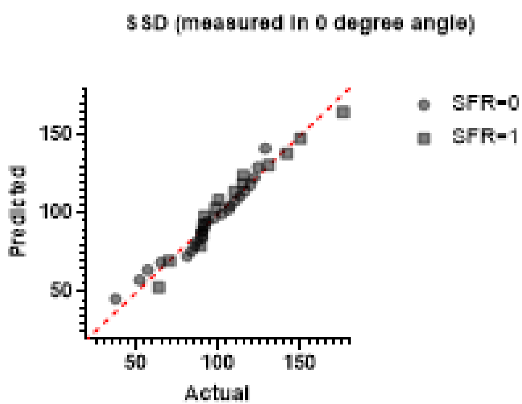

Figure 3. Normal QQ plot of skin-stone distance (measured in 0°), (SFR=0 - non-residual stone group, SFR - residual stone group).

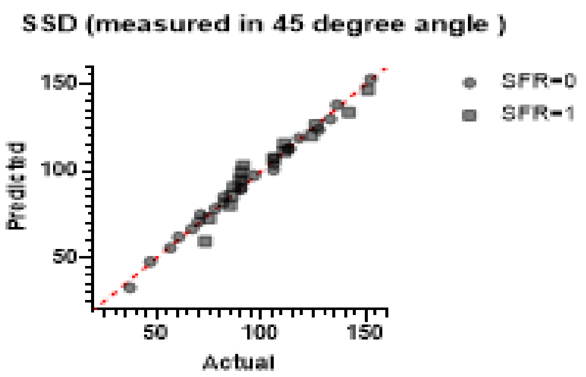

Figure 4. Normal QQ plot of skin-stone distance (measured in 45°), (SFR=0 - non-residual stone group, SFR - residual stone group).

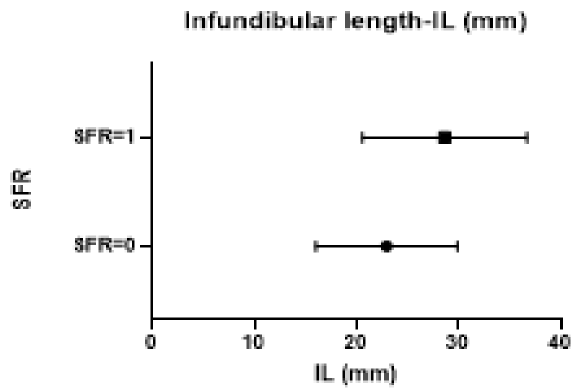

Figure 7. The mean and standard deviation difference of infundibular length in the stone free group, (SFR=0) and the group with residual stone (SFR=1).

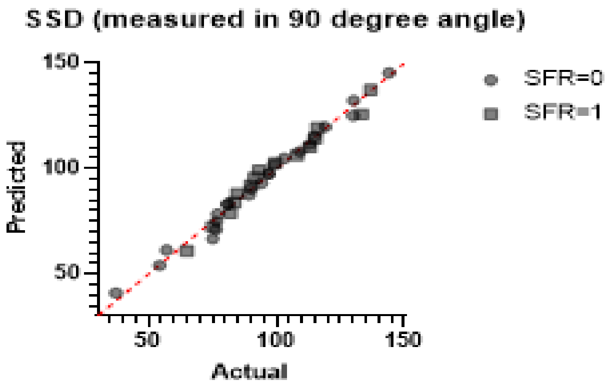

Figure 5. Normal QQ plot of skin-stone distance (measured in 90°), (SFR=0 - non-residual stone group, SFR - residual stone group).

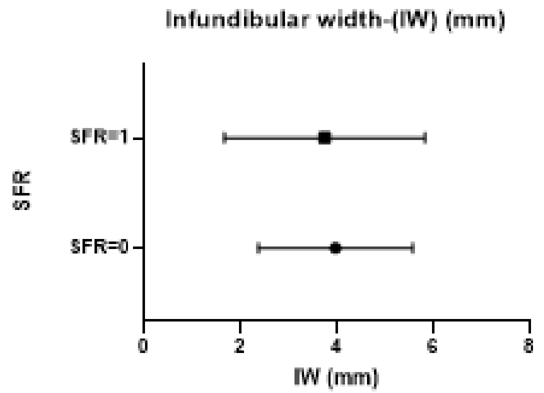

Figure 8. The mean and standard deviation difference of infundindibular width in the stone free group, (SFR=0) and the group with residual stone (SFR=1).

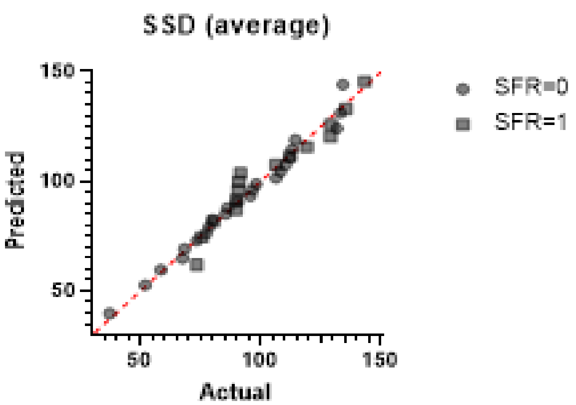

Figure 6. Normal QQ plot of skin-stone distance (average value), (SFR=0 -non-residual stone group, SFR-residual stone group).

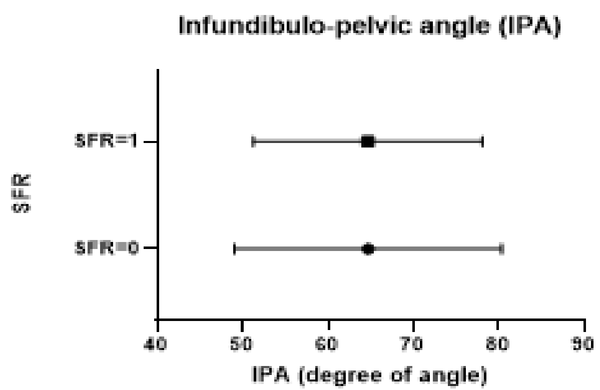

Figure 9. The mean and standard deviation difference of infundibulopelvic angle in the stone free group, (SFR=0) and the group with residual stone (SFR=1).

Table IV. Factors influencing stone-free rate ESWL efficiency in lower pole stone.

ESWL parameters and SFR	
Stone size (Mann-Whitney test)	p=0.8082
Age (Unpaired t-test, Welch correction)	p=0.1386
Localization of the stone (Chi-square test)	p=0.3893
Sex of patients (Chi-square test)	p=0.8222
Presence of double J-stent (Chi-square test)	OR=2.108; CI=1.231-3.703; p=0.0078
BMI (Unpaired t-test, Welch correction)	p=0.002
SSD (avr) (Unpaired t-test)	p=0.1147
SSD (0°) (Unpaired t-test)	p=0.112
SSD (45°) (Mann-Whitney test)	p=0.319
SSD (90°) (Unpaired t-test)	p=0.445
IL (infundibulum length)	p=0.07
IW (infundibulum width)	p=0.7681
IPA (infundibulo-pelvic angle)	p=0.996

Discussion

Earlier studies concluded that the predicting factors for the ESWL success rate were stone size, overweight, use of double J stents, and stone attenuation value (SAV).

Our study had a stone fragmentation success rate of 68.6%, similar to findings in the literature, where it varies between 69% and 79%, always having a lower success rate for other types of kidney stones [4,10].

Stone size can be defined using different parameters, such as length and width, or the maximal stone length.

We did not find any statistically significant difference between the bigger and low stone size groups after we performed Mann Whitney test (Figure 1), similar to many another studies [14,15].

Other studies (Shinde, Yang, and Snicorius et al.) showed a statistically significant difference in success rate between larger and smaller stone sizes [10,11,16].

Overall, the age and sex of the patients do not affect the success rate of ESWL. Shinde et al.'s study showed a threefold higher risk for ESWL failure (odds ratio=3.213, CI=1.194-9.645) [10].

In our study the group of patients with BMI more than 25 kg/m^2 had a lower success rate , which is similar to what Yang et al. proposed, namely that body mass index and buttock circumference can affect the stone-free rate [11].

In the present study, the chi-square test showed a statistically significant difference in the stone-free rate between stented and non-stented patients; it reduced the success rate.

In the study of Shinde et al [10], the number of stented patients (20.6%) was close to the results of our study (18.6%), but they did not observe a difference between stented and non-stented patients. Pettenati et al. showed that stented patients with stones greater than 8 mm had reduced success rates [15].

Ghoneim, Aprali, Erkoc, and Snicorius have demonstrated that the anatomical location of kidney stones can affect the success of their elimination [16–19]. Ghoneim and Aprali et al. analyzed the parameters of intravenous urography (IVU): infundibulum length, width, and infundibulopelvic angle; Erkoc and Snicorius analyzed the parameters of non-contrast computed tomography (NCCT): the average skin-to-stone size measured at 0°, 45° and 90°.

In our study, the average stone-to-skin distance was 94.732 mm which is comparable with the study of Erkoc [19], where the mean skin stone distance was 106.5±15.8 mm. Emiliani et al. researched the phytotherapy use in the treatment of kidney stones, for example Phyllanthus niruri, making the ESWL session more effective, changing the crystallization of the calcium oxalate stones [20].

Conclusions

Single ESWL session often fails stone fragmentation, as this study shows. It can be affected by the position of the stone (lower pole kidney stone), the presence of a double J stent, and obesity.

BMI, as an easily obtained parameter, can predict the success rate of single session ESWL and can guide the urologist to repeat the session, and to achieve stone fragmentation with a minimally invasive procedure.

Acknowledgments

This article extends sincere appreciation to the medical staff of Urology Department in Târgu Mureș.

References

1. Gurocak S, Kupeli B, Acar C, Tan MO, Karaoglan U, Bozkirli I. The impact of pelvicaliceal features on problematic lower pole stone clearance in different age groups. Int Urol Nephrol. 2008;40:31-37.
2. Sampaio FJ, D'Anunciação AL, Silva EC. Comparative follow-up of patients with acute and obtuse infundibulum-pelvic angle submitted to extracorporeal shockwave lithotripsy for lower caliceal stones: preliminary report and proposed study design. J Endourol. 1997;11:157-161.
3. Elbahnasy AM, Shalhav AL, Hoenig DM, Elashry OM, Smith DS, McDougall EM, et al. Lower caliceal stone clearance after shock wave lithotripsy or ureteroscopy: the impact of lower pole radiographic anatomy. J Urol. 1998;159:676-682.
4. Nakada SY, Pearle MS, editors. Surgical Management of Urolithiasis: Surgical Management of Urolithiasis: Percutaneous, Shockwave, and Ureteroscopy. Springer, 2013;13:160-161
5. Kumar A, Kumar N, Vasudeva P, Kumar Jha S, Kumar R, Singh H. A prospective, randomized comparison of shock wave lithotripsy, retrograde intrarenal surgery and miniperc

for treatment of 1 to 2 cm radiolucent lower calyceal renal calculi: a single center experience. J Urol. 2015;193:160-164.

6. Zhang H, Hong TY, Li G, Jiang N, Hu C, Cui X, et al. Comparison of the Efficacy of Ultra-Mini PCNL, Flexible Ureteroscopy, and Shock Wave Lithotripsy on the Treatment of 1-2 cm Lower Pole Renal Calculi. Urol Int. 2019;102:153-159.
7. Golomb D, Goldberg H, Tapiero S, Stabholz Y, Lotan P, Darawsha AE, et al. Retrograde intrarenal surgery for lower pole stones utilizing stone displacement technique yields excellent results. Asian J Urol. 2023;10:58-63.
8. Skolarikos A, Neisius A, Petřík A,Somani B, Thomas K, Gambaro G. EAU Guidelines on Urolithiasis. European Association of Urology. 2023;3.4.6:19-21.
9. Tiselius HG, Ackermann D, Alken P, Buck C, Conort P, Gallucci M. Working Party on Lithiasis, European Association of Urology. Guidelines on urolithiasis. Eur Urol. 2001;40:362-371.
10. Shinde S, Al Balushi Y, Hossny M, Jose S, Al Busaidy S. Factors Affecting the Outcome of Extracorporeal Shockwave Lithotripsy in Urinary Stone Treatment. Oman Med J. 2018;33:209-217.
11. Yang TK, Yang HJ, Lee LM, Liao CH. Body mass index and buttock circumference are independent predictors of disintegration failure in extracorporeal shock wave lithotripsy for ureteral calculi. J Formos Med Assoc. 2013;112:421-425.
12. Danuser H, Müller R, Descoeudres B, Dobry E, Studer UE. Extracorporeal shock wave lithotripsy of lower calyx calculi: how much is treatment outcome influenced by the anatomy of the collecting system? Eur Urol. 2007;52:539-546.
13. Gupta NP, Singh DV, Hemal AK, Mandal S. Infundibulopelvic anatomy and clearance of inferior caliceal calculi with shock wave lithotripsy. J Urol. 2000;163:24–27.
14. Massoud AM, Abdelbary AM, Al-Dessoukey AA, Moussa AS, Zayed AS, Mahmmoud O. The success of extracorporeal shock-wave lithotripsy based on the stone-attenuation value from non-contrast computed tomography. Arab J Urol. 2014;12:155-161.
15. Pettenati C, El Fegoun AB, Hupertan V, Dominique S, Ravery V. Double J stent reduces the efficacy of extracorporeal shock wave lithotripsy in the treatment of lumbar ureteral stones. Cent European J Urol. 2013;66:309-313.
16. Snicorius M, Bakavicius A, Cekauskas A, Miglinas M, Platkevicius G, Zelvys A. Factors influencing extracorporeal shock wave lithotripsy efficiency for optimal patient selection. Wideochir Inne Tech Maloinwazyjne. 2021;16:409-416.
17. Ghoneim IA, Ziada AM, Elkatib SE. Predictive factors of lower calyceal stone clearance after Extracorporeal Shockwave Lithotripsy (ESWL): a focus on the infundibulopelvic anatomy. Eur Urol. 2005;48:296-302; discussion 302.
18. Arpali E, Altinel M, Sargin SY. The efficacy of radiographic anatomical measurement methods in predicting success after extracorporeal shockwave lithotripsy for lower pole kidney stones. Int Braz J Urol. 2014;40:337-345.
19. Erkoc M, Bozkurt M, Besiroglu H, Canat L, Atalay HA. Success of extracorporeal shock wave lithotripsy based on CT texture analysis. Int J Clin Pract. 2021;75:e14823.
20. Emiliani E, Jara A, Kanashiro AK. Phytotherapy and Herbal Medicines for Kidney Stones. Curr Drug Targets. 2021;22:22-30.