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Original Article

Comparison of the outcomes of complete supine percutaneous nephrolithotomy in patients with radiopaque and radiolucent kidney stones

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ABSTRACT

Objective: This study compared the stone opacity effect in patients who had radiopaque and radiolucent stones in percutaneous nephrolithotomy (PCNL) results.

Material and methods: The medical records of 171 complete supine PCNL procedures were gathered. Patients were categorized into two groups: those with radiopaque (n=141) and those with radiolucent (n=30) stones. Kidney, ureter and bladder x-ray was done a day after PCNL and Ultrasound imaging was done two weeks later to evaluate the stone free rate. A stone free result was defined as having less than 4 mm residual stone size. Outcome parameters were compared by univariate analysis and those which were significantly different between the two groups were assessed by multivariate binary logistic regression analysis.

Results: There were no significant differences in age, sex, body mass index, hypertension, diabetes mellitus, pre-surgery hemoglobin, pre-surgery serum creatinine, stone and also surgery-related parameters between the two groups. Stone free rate, surgery time, complication-related parameters, hemoglobin drop, serum creatinine and glomerular filtration rate (GFR) changes were similar in both groups based on univariate analysis. The radiopaque group had higher post-surgery GFR ($p=0.04$) and longer hospital stay ($p=0.009$). However, opacity had no effect on these outcomes after multivariate analysis. Higher post-surgery GFR was seen in patient with higher GFR before surgery ($p<0.0001$). Also, higher hemoglobin before surgery was correlated with less hospital stay ($p=0.001$).

Conclusion: The complete supine percutaneous nephrolithotomy outcomes are similar in patients with radiopaque and radiolucent stones.

Keywords: Kidney stone; percutaneous nephrolithotomy; stone opacity; supine position.

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Introduction

Urinary stone is a common problem in the world with an increasing prevalence and incidence rate.[1] It can damage life quality and socio-economic status.[1,2] Factors such as burden, hardness, stone location and hydronephrosis degree are influential in selecting a proper treatment method.[3] Because of less morbidity, costs and recovery period, percutaneous nephrolithotomy (PCNL) is used as an alternative to open surgery in patients who are not ideal candidates for extracorporeal shock wave lithotripsy (ESWL) and is the treatment of choice in patients with large or complex stones.[4,5]

Percutaneous nephrolithotomy has many advantages in supine position compared to the traditional prone position and it is safe and easy for all the patients. There is no need for changing the patient's position during the procedure. The benefits of complete supine PCNL are similar to other types of supine positions. Moreover, puncturing the upper kidney pole would be easier because of the flank support absence which could prevent the kidney from cephalad sliding. Lung inflation is suggested for moving down the kidney, so the upper kidney pole puncturing would be more feasible. Complete supine PCNL would have a better kidney fluoroscopic view compared to semi-supine position because the vertebra would not overlap the fluoroscopic view.[6,7]

Stone composition has been used to anticipate the success rate of ESWL. However, it has been found that the stone construction is more important than its composition. So, stone construction has become a remarkable feature for predicting treatment outcomes in recent years.[3] Knowing the urinary tract stones' opacity provides great information for urologists to choose a proper treatment and appropriate imaging during follow up.[8] Still, in spite of doing several researches,[9-11] the correlation between stone opacity and a special range of Hounsfield unit scales (measured by computed tomography scan) has not been understood well.[8]

So far, some studies have investigated stone opacity effect on ESWL outcomes.[12,13] Also, some other studies have studied the relationship between stone density and ESWL or PCNL outcomes.[14-17]

To our knowledge, no study has compared the results of PCNL in patients with radiopaque and radiolucent stones. The authors of this study had some presumptions about the probable effects of stone opacity on PCNL results. So, this study compared the stone opacity effect in patients who had radiopaque and radiolucent stones in PCNL results.

Material and methods

In this cross-sectional analytical study, all data were extracted from 171 medical records of patients who had undergone complete supine PCNL between January 2013 and March 2016 in a hospital in Rasht city, Iran. One surgeon did all the surgeries. Inclusion criteria were having: 1) kidney stone burden >20 mm, 2) stone burden >15 mm in lower kidney pole, 3) complex stones and 4) no successful ESWL results. However, pregnant women, patients with uncontrolled bleeding disorders, untreated urinary tract infection and severe immunosuppression (such as HIV or immunosuppressive drugs administrations) were excluded from the study.

Patients were divided into two groups: radiopaque (n=141) and radiolucent (n=30) groups based on kidney, ureter and bladder radiography results before the surgery. Also, ultrasound was done for all patients and intra-venous urography or computed tomography scans were done before the surgery if needed.

All the complete supine PCNLs were done under general anesthesia. The procedure began with cystoscopy and insertion of a retrograde ureteral stent. Then patients were placed at bed's edge in complete supine position, not needing flank support nor changing legs' position. Between posterior and middle axillary line, 18-gauge needle was applied for achieving the collecting system puncture under fluoroscopy guide. Subcostal access was done in all patients. Our method for dilating the access pathway was one-shot dilation. 30 Fr Amplatz sheath was inserted through the access line. Lithotripsy was done by pneumatic devices.[18] Nephrostomy tube and multiple tract insertion were applied according to the surgeon's preference. Blood was transfused in patients with severe blood loss, causing unstable hemodynamic state and post-operation hemoglobin level less than 10 mg/dL. The first or second day after the surgery, Foley catheter and external ureteral stent were removed, except in cases with significant complications such as severe blood loss or gross hematuria and urinary leakage.

To evaluate the final stone free rate results, kidney, ureter and bladder radiography and ultrasound were done the day after the surgery and two weeks later, respectively. Stone free result was considered as residual stone size less than 4 mm. Disparity more than 5.31% between pre- and post-surgery glomerular filtration rate (GFR) was applied for classifying GFR changes in three groups (decreased, increased or without change).[19]

Demography, surgery, medical history, and stone-related features plus outcomes after complete supine PCNL were recorded in a data collection form. The confidentiality of all information was preserved. Since this was a retrospective study, the formal consent was not required. The institutional review board and ethics committee of our university approved the study protocol (IR.GUMS.REC.1394.439).

Statistical analysis

All data were analyzed by statistical package for social sciences IBM Statistical Package for the Social Sciences (IBM SPSS Statistics; Armonk, NY, USA) software version 22.0. Univariate statistical tests, such as Chi-Square and Fisher's Exact (for qualitative variables), Kolmogorov-Smirnov (to determine the normal distribution) and independent-t (for quantitative variables), Mann-Whitney U test (for quantitative variables with non-normal distribution), were used to evaluate the data in both groups. Also, the multivariate analysis using binary logistic regression was applied to predict the relationship between stone opacity and PCNL outcomes. Outcomes which were significantly different between the groups in the univariate analysis were assessed by the binary logistic regression analysis. Covariates with $p<0.25$ in the univariate analysis were entered into the binary logistic regression model (with forward-LR method and stepwise probability: entry: 0.05- removal: 0.1). In this model,

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quantitative outcome variables were classified into two groups based on the total variable mean. Code 0 was considered for quantities less than mean and code 1 for equal or more amounts. P values less than 0.05 were considered significant.

Results

A number of 171 patients with kidney stones who had undergone complete supine PCNL were enrolled in this retrospective study. The means of age and body mass index were 49.41±13.9 years old and 28.14±4.70 kg/m^2 in radiopaque group and 51.50±14.1 years old and 29.96±5.61 kg/m^2 in radiolucent group, respectively. The means of stone burden were 35.86±14.3 and 37.85±14.68 mm in the radiopaque and radiolucent groups, respectively (p=0.429). In both groups, the most frequent stone location belonged to multiple location stones (57.8%). There were no significant differences in access calyx, number of access (multiple or single) and tubeless approach between the two groups (Table 1). The mean of surgery time was 55.06±28.9 minutes in radiopaque group and 52.27±29.66 minutes in radiolucent group (p=0.481).

The means of serum creatinine were 1.06±0.36 and 1.16±0.32 mg/dL before surgery (p=0.079) and 1.07±0.36 and 1.12±0.29 mg/dL after surgery in radiopaque and radiolucent groups (p=0.112), respectively. Creatinine level was not significantly different before and after the surgery between the two groups. Also, the means of GFR were 74.54±19.93 vs. 64.27±19.46 mL/min before surgery (p=0.011) and 74.42±20.77 vs. 65.91±18.83 mL/min after surgery (p=0.040) in radiopaque and radiolucent groups, respectively. The GFRs were higher in radiopaque group before and after the surgery. Also, in the classified GFR categories (Table 2) most of the cases in radiopaque and radiolucent groups, 46.1% vs. 63.3%, were in the "without change" category after PCNL. 29.8% vs. 26.7% of the patients in radiopaque and radiolucent groups were classified in the "increased" GFR group and 24.1% vs. 10% of cases in radiopaque and radiolucent groups were in "decreased" GFR group. The means of hemoglobin level were 13.07±1.72 vs. 12.61±1.80 g/dL in radiopaque and radiolucent groups before the surgery, respectively (p=0.216). The mean of hemoglobin had dropped 1.28±1.21 g/dL in radiopaque group and 1.00±0.89 g/dL in radiolucent group after the surgery (p=0.330).

There was no significant difference regarding complications and their Clavien classification between the two groups. The fever prevalence (10.6% vs. 13.3%; p=0.749) and blood loss requiring transfusion (12.8% vs. 13.3%; p=1.000) were not significantly different between radiopaque and radiolucent groups.

In univariate analysis, the mean of post-surgery GFR (p=0.040), and the duration of hospital stay (p=0.009) after surgery were significantly different between the two groups. The mean of GFR in radiopaque group (74.42±20.77 mL/min) was more than radiolucent group (65.91±18.83 mL/min). The hospital stay duration in radiopaque group (2.01±1.32 mL/min) was longer than radiolucent group (1.40±0.67 mL/min). However, there was no significant difference between the two groups in the other outcome variables (Table 2).

The mean of GFR was 73 mL/min totally. Finally, the main variable (opacity) was not a predictive factor for post-surgery GFR in multivariate analysis. Only GFR before surgery was a predictor for post-surgery GFR (p<0.0001). In other words, one unit rise in GFR before surgery would increase the chances of having a GFR more than mean after the surgery; odds ratio (OR): 1.10, 95% confidence interval for OR: 1.068-1.133.

The mean of hospital stay was two days. The stone opacity effect (the main variable) was not significant on hospital stay duration in the final logistic regression model. Patients with a history of urinary tract infection, p=0.002, OR: 10.667, 95% confidence interval for OR: 2.344-48.549, or with higher hemoglobin level before the surgery, p=0.001, OR: 0.672, 95% confidence interval for OR: 0.533-0.849, had a lower chance of staying in hospital more than two days. There was no indication for doing open surgery during the PCNL in any patient.

Discussion

It is better to know the opacity of urinary tract stones to choose a proper treatment and an appropriate imaging during follow up.[8] To our knowledge, no study has exclusively assessed the stone opacity effect on PCNL outcomes. We found no significant difference in the stone free rates between our studied groups in univariate analysis. Also, no correlation was found between ESWL success rates and stone opacity in two other studies.[13,20]

Operation time was not different between the two groups in univariate analysis in our study. Falahatkar et al.[21] also did not report any relationship between surgery time and stone opacity in complete supine PCNL procedures. This finding was contrary to our presumption about the more feasibility of non-opaque stones fragmentation than opaque ones and also our expectance of shortening the PCNL surgery time in lucent stones.

In our study, blood transfusion rate was not significantly different after PCNL in both groups. Akman et al.[22] arrived at similar results. Also, there was no significant relationship between GFR categories' changes, catheter removing time, complication, Clavien classification, fever, post-surgery creatinine and stone opacity in univariate analysis. In our study, the post-surgery GFR was higher in radiopaque group. However, this correlation was rejected by multivariate regression analysis. Higher GFR

Table 1. Demography, surgery, medical history and stone related features

Variable		Radio opaque (n=141)	Radio lucent (n=30)	p
Mean, age±SD (year)		49.41±13.90	51.50±14.10	0.457[a]
Gender, n (%)	Male	69 (48.9)	11 (36.7)	0.221[b]
	Female	72 (51.1)	19 (63.3)	
Mean, BMI±SD (kg/m^2)		28.14±4.70	29.96±5.61	0.105[a]
BMI group, n (%)	<25	37 (26.2)	4 (13.3)	0.175[b]
	25-29.9	56 (39.7)	11 (36.7)	
	= or >30	48 (34.0)	15 (50.0)	
Mean preoperative, Hb±SD (g/dL)		13.07±1.72	12.61±1.80	0.216[a]
Mean preoperative serum, Cr±SD (mg/dL)		1.06±0.36	1.16±0.32	0.079[c]
Mean preoperrative, GFR±SD (mL/min)		74.54±19.93	64.27±19.46	0.011[a]
UTI history, n (%)	No	112 (79.4)	19 (63.3)	0.059[b]
	Yes	29 (20.6)	11 (36.7)	
DM, n (%)	No	110 (78.0)	19 (63.3)	0.090[b]
	Yes	31 (22.0)	11 (36.7)	
HTN, n (%)	No	94 (66.7)	15 (50.0)	0.085[b]
	Yes	47 (33.3)	15 (50.0)	
IHD, n (%)	No	129 (91.5)	26 (86.7)	0.487*
	yes	12 (8.5)	4 (13.3)	
Mean stone, burden±SD		35.86±14.30	37.85±14.68	0.429[c]
Stone operation history, n (%)	No	104 (73.8)	19 (63.3)	0.249[b]
	Yes	37 (26.2)	11 (36.7)	
ESWL history, n (%)	No	106 (75.2)	21 (70.0)	0.556[b]
	Yes	35 (24.8)	9 (30.0)	
PCNL side, n (%)	Right	78 (55.3)	18 (60.0)	0.639[b]
	Left	63 (44.7)	12 (40.0)	
Stone number, n (%)	Single	35 (24.8)	7 (24.1)	0.833[b]
	Multiple	106 (75.2)	22 (75.9)	
Staghorn stone, n (%)	None	133 (94.3)	26 (86.7)	0.076*
	Yes	8 (5.7)	3 (10.0)	
Complex stone, n (%)	No	53 (37.6)	9 (30.0)	0.432[b]
	Yes	88 (62.4)	21 (70.0)	
Target calyx, n (%)	Upper	10 (7.1)	3 (10.0)	0.561*
	Middle	28 (19.9)	6 (20.0)	
	Lower	96 (68.1)	18 (60.0)	
	multiple access	7 (5.0)	3 (10.0)	
Multiple tract access, n (%)	No	130 (92.2)	26 (86.7)	0.304*
	Yes	11 (7.8)	4 (13.3)	
Nephrostomy, n (%)	No	137 (97.2)	30 (100.0)	1.000*
	Yes	4 (2.8)	0 (0.0)	
Grade of hydronephrosis, n (%)	Mild	32 (29.0)	8 (28.6)	0.085*
	Mod	45 (42.1)	15 (53.6)	
	Severe	30 (28.0)	5	(14.3)

[a]Independent t-test, [b]Chi-square test, [c]Mann-Whitney U test, *Fisher-exact test. SD: standard deviation; BMI: body mass index; Hb: hemoglobin; Cr: creatinine; GFR: glomerular filtration rate; UTI: urinary tract infection; DM: diabetes mellitus; HTN: hypertension; IHD: ischemic heart disease; ESWL: extra corporeal shockwave lithotripsy; PCNL: percutaneous nephrolithotomy

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Table 2. Outcomes after complete supine PCNL in the studied groups (univariate analysis)

Outcome variables		Radiopaque group (n=141)	Radiolucent group (n=30)	p
GFR changes groups, n (%)	Without change	65 (46.1)	19 (63.3)	0.145[a]
	Increased	42 (29.8)	8 (26.7)	
	Decreased	34 (24.1)	3 (10.0)	
Stone free rate, n (%)	Stone free	131 (92.9)	29 (96.7)	0.691[b]
	Residual stone >4 mm	10 (7.1)	1 (3.3)	
Catheter removing time, n (%)	PO1	82 (58.2)	24 (80.0)	0.168[b]
	PO2	41 (29.1)	5 (16.7)	
	PO3	17 (12.1)	1 (3.3)	
	PO4	1 (0.7)	0 (0.0)	
Complication, n (%)	No	112 (79.4)	22(73.3)	0.461[a]
	Yes	29 (20.6)	8 (26.7)	
Colon injury, n (%)	0 (0.0)	0 (0.0)	-	
Visceral injury, n (%)	0 (0.0)	0 (0.0)	-	
AV fistula and pseudoaneurysm, n (%)	0 (0.0)	0 (0.0)	-	
Clavien classification of complications, n (%)	No complication	113 (80.1)	22 (73.3)	0.610[b]
	Class 1	9 (6.4)	3 (10.0)	
	Class 2	16 (11.3)	4 (13.3)	
	Class 3	2 (1.4)	1 (3.3)	
	Class 5	1 (0.7)	0 (0.0)	
Transfusion, n (%)	No	123 (87.2)	26 (86.7)	1.000[b]
	Yes	18 (12.8)	4 (13.3)	
Fever, n (%)	Yes	15 (10.6)	4 (13.3)	0.749[b]
	No	126 (89.4)	26 (86.7)	
Mean post-op, GFR±SD (mL/min)		74.42±20.77	65.91±18.83	0.040[c]
Mean post-op serum, Cr±SD (mg/dL)		1.07±0.36	1.12±0.29	0.112[d]
Mean GFR changes±SD (mL/min)		-0.18±13.35	1.64±10.46	0.786[d]
Mean Hb drop±SD (g/dL)		1.28±1.21	1.00±.89	0.330[d]
Mean operative time (min)±SD		55.06±28.90	52.27±29.66	0.481[d]
Mean post-op hospitalization (day)±SD		2.01±1.32	1.40±0.67	0.009[d]

[a]Chi-square test, [b]Fisher-exact test,[c]Independent t- test, [d]Mann-Whitney U test. GFR: glomerular filtration rate; AV fistula: arteriovenous fistula; Post-op: Post-operative; Cr: creatinine; SD: standard deviation; Hb: hemoglobin; PCNL: percutaneous nephrolithotomy

before surgery was the positive predictive factor for higher post-surgery GFR.

Our study revealed that, hypertension or diabetes mellitus have no adverse effect on the post-surgery GFR. These findings are consistent with Tabibi et al.[23] findings. Although, these diseases may occur with or without other comorbidities, we did not consider the confounding effect of coexistence of different diseases which could have been a potential risk factor for GFR decrease. Also, the current severity of the comorbidities was not classified and we did not separate patients with comorbidities who were under medical treatment from others who were not. Possibly, in a larger sample size or in a more accurate classification of comorbidities which might affect post-surgery GFR, the results might be different. However, GFR changes more than 5.3% of its baseline were considered as a significant change in kidney function regarding the classification which we used.[19]

Sharifiaghdas et al.[24] evaluated the tubular damage after PCNL by measuring the level of ß2-microglobulin as a marker in the early period after surgery. They found that the possibility of tubular damage was higher in those with diabetes mellitus history and higher serum creatinine before surgery.

The mean of hospital stay after PCNL was more in radiopaque than radiolucent group, but this was rejected by multivariate analysis too. In our study, body mass index had no relationship with hospital stay similar to other studies.[25-27] Olbert et al.[28] found little evidence in the possibility of prolonging hospital stay in patients with lower body mass indexes. Faerber et al.[29] observed longer hospital stay in the morbidly obese patients compared to others with normal weight.

In our study, patients with no history of urinary tract infection seemed to have longer hospital stay. Also, we did not find any relationship between the hydronephrosis grade before surgery and hospital stay. However, Olbert et al.[28] found no relationship between hospital stay period and urinary tract infection history based on the univariate and multivariate analysis outcomes. Hydronephrosis grade was not correlated with hospital stay according to Akman et al.[30] study using univariate and multivariate analysis. Our different results in hospital stay can be because of various factors which could affect the physicians' decision in choosing the proper treatment approach (inpatient, outpatient or referring patients to other therapeutic medical services). The decision could vary according to a physician's preference based on patient's conditions. Similar to another study, we found that hospital stay was not affected by hypertension history.[30]

Our results showed that lower hemoglobin before surgery is a predictive factor for prolonging hospital stay. Since in a study low hemoglobin before surgery was a predictor of blood transfusion requirement in the first 48 hours after the surgery,[22] the necessity for transfusion could prolong the hospital stay period.

A limitation of our study was that the patients were not evaluated by computed tomography scan because of economic issues. This scan has lower acceptance among patients in our population because of being expensive. So, ultrasound and kidney, ureter and bladder radiography were used to evaluate treatment response to have a larger sample size. The relative small sample size in radiolucent group and the imprecise classification of the comorbidities were the other limitations of this study.

In conclusion, there was no significant correlation between stone opacity and PCNL outcomes. Although, post-surgery GFR and hospital stay were more in the patients with radiopaque stones based on univariate analysis, these results were rejected by multivariate analysis. Further studies with a larger sample size, appropriate comorbidities classification, and applying computed tomography scan are recommended.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Guilan University of Medical Sciences (IR.GUMS.REC.1394.439).

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

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References

1. Knoll T. Epidemiology, pathogenesis, and pathophysiology of urolithiasis. Eur Urol Suppl 2010;9:802-6. [CrossRef]
2. Lingeman JE, Coury TA, Newman DM, Kahnoski RJ, Mertz JH, Mosbaugh PG, et al. Comparison of results and morbidity of percutaneous nephrostolithotomy and extracorporeal shock wave lithotripsy. J Urol 1987;138:485-90. [CrossRef]
3. Eichel L, Clayman RV. Percutaneous Stone Removal. In: Nakada S Y, Pearl M, editors. Advanced Endourology. Totowa: Humana Press Inc; 2006.p.121-4. [CrossRef]
4. Darabi Mahboub MR, Shakibi MH. Percutaneous nephrolithotomy in patients with Solitary Kidney. J Urol 2008;5:24-7.
5. Segura JW. The role of percutaneous surgery in renal and ureteral stone removal. J Urol 1989;141:780-1. [CrossRef]
6. Falahatkar S, Allahkhah A, Soltanipour S. Supine Percutaneous Nephrolithotomy PRO. Urol J 2011;8:257-64.
7. Karaolides T, Moraitis K, Bach C, Masood J, Buchholz N. Positions for percutaneous nephrolithotomy: Thirty-five years of evolution. Arab J Urol 2012;10:307-16. [CrossRef]
8. Gucuk A, Uyeturk U. Usefulness of hounsfield unit and density in the assessment and treatment of urinary stones. World J Nephrol 2014;3:282-6. [CrossRef]
9. Spettel S, Shah P, Sekhar K, Herr A, White MD. Using hounsfield unit measurement and urine parameters to predict uric acid stones. J Urol 2013;82:22-6. [CrossRef]
10. Chua ME, Gatchalian GT, Corsino MV, Reyes BB. Diagnostic utility of attenuation measurement (Hounsfield units) in computed tomography stonogram in predicting the radio-opacity of urinary calculi in plain abdominal radiographs. Int Urol Nephrol 2012;44:1349-55. [CrossRef]

Turk J Urol 2017; 43(4): 490-6
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11. Huang CC, Chuang CK, Wong YC, Wang LJ, Wu CH. Useful prediction of ureteral calculi visibility on abdominal radiographs based on calculi characteristics on unenhanced helical CT and CT scout radiographs. Int J Clin Pract 2009;63:292-8. [CrossRef]
12. Cimentepe E, Unsal A, Saglam R, Balbay MD. Comparison of clinical outcome of extracorporeal shockwave lithotripsy in patients with radiopaque v radiolucent ureteral calculi. J. Endourol 2003;17:863-5. [CrossRef]
13. Abid AF. Success factors of extracorporeal shock wave lithotripsy for renal & ureteric calculi in adult. Sci Res 2014;4:26-32. [CrossRef]
14. Arshadi H, Dianat SS, Ganjehei L. Accuracy of radiological features for predicting extracorporeal shock wave lithotripsy success for treatment of kidney calculi. J Urol 2009;6:88-91.
15. Hong Lim K, Jung JH, Kwon Hyun J, Seok Lee Y, Bae J, Chul Cho M, et al. Can stone density on plain radiography predict the outcome of extracorporeal shockwave lithotripsy. Korean J Urol 2015;56:56-62. [CrossRef]
16. Anastasiadis A, Onal B, Modi P, Turna B, Duvdevani M, Timoney A, et al. Impact of stone density on outcomes in percutaneous nephrolithotomy (PCNL): an analysis of the clinical research office of the endourological society (CROES) pcnl global study database. Scand J Urol 2013;47:509-14. [CrossRef]
17. Gücük A, Uyetürk U, Oztürk U, Kemahli E, Yildiz M, Metin A. Does the Hounsfield unit value determined by computed tomography predict the outcome of percutaneous nephrolithotomy? J Endourol 2012;26:792-6. [CrossRef]
18. Falahatkar S, Moghaddam AA, Salehi M, Nikpour S, Esmaili F, Khaki N. Complete Supine Percutaneous Nephrolithotripsy Comparison with the Prone Standard Technique. J Endourol 2008;22:2513-7. [CrossRef]
19. Shokeir AA, GAD HM, el-Diasty T. Role of radioisotope renal scans in the choice of nephrectomy side in live kidney donors. J Urol 2003;170:373-6. [CrossRef]
20. El-Assmy A, El-Nahas AR, Abo-Elghar ME, Eraky I, El-Kenawy MR, Sheir KZ. Predictors of success after extracorporeal shock wave lithotripsy for renal calculi between 20–30 mm: a multivariate analysis model. TSW Urology 2006;6:2388-95. [CrossRef]
21. Falahatkar S, Moghaddam KG, Kazemnezhad E, Enshaei A, Asadollahzade A, Farzan A, et al. Factors affecting operative time during percutaneous nephrolithotomy: our experience with the complete supine position. J Endourol 2011;25:1831-6. [CrossRef]
22. Akman T, Binbay M, Sari E, Yuruk E, Tepeler A, Akcay M, et al. Factors affecting bleeding during percutaneous nephrolithotomy: single surgeon experience. J Endourol 2011;25:327-33. [CrossRef]
23. Tabibi A, Khazaeli M, Modir A, Abedi A, Nabavizadeh P, Soltani MH. Early effects of percutaneous nephrolithotomy on glomerular filtration rate and determining the potential risk factors responsible for acute postoperative renal function impairment. Novelty in Biomedicine 2014;3:95-101.
24. Sharifiaghdas F, Kashi AH, Eshratkhah R. Evaluating percutaneous nephrolithotomy-induced kidney damage by measuring urinary concentrations of β2-microglobulin. Urol J 2011;8:277-82.
25. Shohab D, Ayub R, Alam MU, Butt A, Sheikh S, Assad S, et al. Effect of body mass index on operative time, hospital stay, stone clearance, postoperative complications, and postoperative analgesic requirement in patients undergoing percutaneous nephrolithotomy. Turk J Urol 2015;41:177-80. [CrossRef]
26. Koo BC, Burtt G, Burgess NA. Percutaneous stone surgery in the obese: outcome stratified according to body mass index. BJU Int 2004;93:1296-9. [CrossRef]
27. Fuller A, Razvi H, Denstedt JD, Nott L, Pearle M, Cauda F, et al. The CROES percutaneous nephrolithotomy global study: the influence of body mass index on outcome. J Urol 2012;188:138-44. [CrossRef]
28. Olbert PJ, Hegele A, Schrader AJ, Scherag A, Hofmann R. Pre- and perioperative predictors of short-term clinical outcomes in patients undergoing percutaneous nephrolitholapaxy. Urol Res 2007;35:225-30. [CrossRef]
29. Faerber GJ, Goh M. Percutaneous nephrolithotripsy in the morbidly obese patient. Tech Urol 1997;3:89-95.
30. Akman T, Binbay M, Yuruk E, Sari E, Seyrek M, Kaba M, et al. Tubeless procedure is most important factor in reducing length of hospitalization after percutaneous nephrolithotomy: results of univariable and multivariable models. J Urol 2011;77:299-304. [CrossRef]