Predictive Factors of the Outcomes of Percutaneous Nephrolithotomy for Staghorn Renal Stones

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ABSTRACT

Background: Staghorn calculi comprise complete and partial forms. Complete staghorn stones occupy the renal pelvis and the caliceal system, or more than 80% of the renal collecting system. Before the advent of endourology, staghorn stones had not always been managed since the operative morbidity was high and attaining stone-free status was difficult.

Aim of the study: Is to identify factors that influence stone-free rates (SFRs) and complications in patients who have staghorn stones and have undergone percutaneous nephrolithotomy (PCNL)

Patients and Methods: A retrospective case control study of individuals who had PCNL for staghorn stones, between January 2017 and January 2021 were used to create a database. The study comprised 206 individuals (99 men and 107 women) who had an average (SD) age of 44.80±12.08 years and had staghorn stones in the renal pelvis that had branched into more than one major calyces and borderline staghorn stones(renal pelvic stone that had branched into only one major calyx). An expert endourologist conducted or supervised the PCNL. Every perioperative complication has been documented. Following PCNL, the condition of stone-free has been assessed.

Results: The SFRs following the initial PCNL procedure were successful in 137 patients (66.5%). Twenty-three patients (11.2%) needed a 2nd look at PCNL. The total SFR following the 2nd look PCNL was 73.3%. The most intraoperative complication was hemorrhage (8.7%), followed by pelvic perforation (3.4%). Colon injury was reported in (1.5%) of the cases. Postoperative complications were reported in 25 cases. Fever (5.3%), followed by persistent urine leakage (3.9%).The multivariate analysis revealed that ischemic heart disease (p=0.033), stone diameter >4.5 cm (p<0.001), stone density >900 HU (p=0.005), and complete staghorn stone (p=0.002) were the independent factors inversely affect the stone-free status.

Conclusion: Ischemic heart disease, stone diameter, stone density, and complete staghorn stone were the independent factors affect the stone-free status.

Keywords: *Percutaneous nephrolithotomy ; Staghorn stones ; Predictive Factors.*

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INTRODUCTION

Staghorn calculi comprise complete and partial forms. Complete staghorn stones occupy the renal pelvis and the caliceal system, or more than 80% of the renal collecting system. While partial staghorn stones occupy the renal pelvis and at least two calices. [1] Before the advent of endourology, staghorn stones had not always been managed since the operative morbidity was high and attaining stone-free status was difficult.[2]

Staghorn stones, if left untreated, are linked to recurrent urinary tract infections, urosepsis, and renal dysfunction, renal loss, end-stage renal illness, and a higher likelihood of death.[3] However, nonoperative management may not be as harmful as previously suggested, especially for unilateral staghorn stones; and it is a prudent consideration in those of the highest surgical and anesthetic risk.[4] In spite of developments in equipment and technology, staghorn stone treatment remains a challenge. PCNL monotherapy, single-tract PCNL plus flexible nephroscopy, multitrack PCNL, combinations of PCNL and extracorporeal shock-wave lithotripsy (ESWL), ESWL monotherapy, and open surgery procedures are among the therapeutic options available for staghorn stones. Percutaneous nephrolithotomy (PCNL) must be performed to treat large-volume and staghorn stones, as per current recommendations. [5,6]

The success of PCNL is dependent on several factors, e.g., patient clinical characteristics and associated co-morbidities, stone characteristics, and surgery-related variables (number of access points, access site, tract length, operating time, as well as surgeon's expertise).[7,8,9] Despite the fact that numerous studies have assessed the factors predicting the outcome of PCNL, the number of studies studying factors influencing PCNL outcomes in patients having staghorn stones is limited.

The study aims to identify factors that influence stone-free rates and complications in patients who have complete or partial staghorn renal stones and have undergone PCNL.

PATIENTS AND METHODS

The Urology Department, Al-Hussein and Sayed Galal, Al-Azhar University Hospitals, Cairo, Egypt, conducted this case-control study. Data was collected from all adult patients that received PCNL between January 2017 and January 2021. Patients with incomplete medical records and/or perioperative imaging and renal malformation were excluded.

The study protocol was accepted by our institution's research ethics committee. All data was de-identified and coded before being entered into the program. The data recorded was only accessible to authorized users.

PCNL Procedure:

As part of the pre-PCNL imaging examinations, all patients in our practise underwent CT scans. A normal before-surgery coagulation profile as well as a negative urine culture have been confirmed prior to PCNL procedures, and a single dosage of IV broad-spectrum antibiotic has been given at the time of anesthesia.

Standard prone PCNL was done for all patients.

If there was a targeted significant residual fragment(s), the catheters were left in situ for 2nd look PNL. The need for a 2nd look PCNL was decided according to the postoperative imaging and the opinion of the main surgeon.

Patients who had a persisting burden following the 2nd look PCNL were followed in the clinic and received supplementary treatments such as ESWL, RIRS, and medical treatment as needed.

Patient's medical records were reviewed for:

Preoperative Data: Patients demographics and clinical characteristics were collected (Age, Gender**,** BMI**,** History of ipsilateral renal procedure**,** History of chronic medical disease**,** Main presenting symptoms**,** Haemoglobin**,** Serum creatinine)

Renal and stone parameters were measured (Kidney size, Degree of hydronephrosis, Parenchymal thickness, Stone location, Stone size, Complete or partial staghorn stone, Stone density

Operative Data: include (Percutaneous access level, Calyceal access level, Number of tracks, Track dilation method, need for JJ ureteral stenting, Operative time, Blood transfusion requirement and number of units transfused, Surgeon experience, Intraoperative complications).

Postoperative Data: include (Stone free status**,** need for 2nd look PCNL, Hospital stay, Postoperative complications, Need for ancillary procedures)

The length of stay in the hospital was calculated from the time of surgery to the time of discharge.

The operative time was determined from the time of the P/C puncture to the conclusion of the procedure.

On postoperative imaging studies, stone-free was identified as no detected stone (s) or clinically non-significant residual fragment (s) of <4 mm.

The perioperative complications were categorized and graded using the modified Clavien classification system (MCCS).[10]

Data Analysis:

Using the statistical package for social science (SPSS) version 25 program, the data has been organised, tabulated, and statistically analysed (SPSS Inc, USA).

Microsoft Excel for Windows 10 was used for the construction of a bar chart.

Descriptive statistics have been computed for all research variables, and all quantitative variables have been subjected to a test of normality.

The median, range, and mean ± standard deviation (SD) have been employed to express continuous data (SD). The numbers (percentages) have been employed to represent categorical data.

The primary endpoint was the stone-free status. The study subjects have been divided into two groups: those with residual stones and those who were stone-free (according to the postoperative imaging study after the initial PCNL).

To compare numerical variables between the two groups, the Student t-test or Mann-Whitney U-test have been employed.

The categorical variables have been compared between the two groups using the Chi-Square or Fisher exact test.

A logistic regression analysis has been used to evaluate the predictors of a stone-free state following PCNL. First, univariate analysis was performed for all variables expected to affect the stone-free status. In a logistic multivariable regression stepwise model, significant factors on univariate analysis have been incorporated.

In regression analysis, the data were presented by odds ratio (OR) and its confidence interval (CI).

The findings of significance tests are expressed as two-tailed probability. The obtained results have been deemed significant at the 5% level.

The findings of data analysis were presented in the text, tables, or figures as appropriate.

RESULTS

During the study period, 516 patients were subjected to standard PCNL. Of them, 237 have complete or partial staghorn stones and have been screened for eligibility. Thirty-one patients were omitted owing to incomplete medical records and/or perioperative imaging; thus, 206 data sets were analyzed.

Preoperative Data:

The average age of the patients in the study was 44.80±12.08 years. Overall, 48.1% were males, 51.9% were females, 24.8% had chronic medical comorbidity, and 26.7% were obese. Thirty-three (16.0%) patients reported a previous history of ipsilateral renal procedures.

All patients had normal hemoglobin levels, and only 19 patients (9.2%) had an elevated serum creatinine above the normal value.

According to Pre-operative imaging, 26 patients (26.6%) had complete staghorn stones. The average stone size was 4.75±1.20, and the mean HU was 924.05±346.84. Forty-nine patients (23.8%) had a radiolucent stone, and 105 patients (51.0%) had different degrees of hydronephrosis. Renal atrophy was detected in only 7 patients.

Operative Data:

Most PCNL procedures were performed by experienced urologists in 64.1% of cases. Thirty-two patients (15.5%) needed supracostal access. The calyceal access was performed under fluoroscopy through the lower calyx in 64.6%, the middle calyx in 35.0%, and the upper calyx in 33.8%.

For track formation, serial track dilation was performed using Alken metal dilators in 77.2% of cases and acute dilation using plastic Amplatz dilator in 22.8%.

At the conclusion of the technique, JJ ureteral stent was fixed in 48 patients (23.3%). The main indication of JJ ureteral stenting is unknown due to lack of documentation. Only 11 patients (5.3%%) needed blood transfusion with a median number of 1.00 unit.

The most common intraoperative complication was bleeding (8.7%), followed by pelvic perforation (3.4%). Colon injury was reported in 3 cases (1.5%).

Early Post-Operative Data:

In patients who did not need a second look PCNL, the nephrostomy tubes were removed after a mean period of 3.36±1.22 days (median: 3.00; range: 2.00 to 8 days).

Postoperative complications were reported in 25 cases. Fever (5.3%), followed by persistent urine leakage (3.9%), was the most prevalent postoperative complication.

Stone Free Rate and Ancillary Procedures:

The initial PCNL procedure was successful in 137 patients (66.5%). Twenty-three patients (11.2%) needed a 2nd look PCNL. From them, 14 patients were rendered stone-free. The SFR following the 2nd look PCNL was 73.3%.

Out of 55 patients with significant residual stones after the 2nd look PCNL, 32 (58.2%) underwent ESWL, 4 (7.3%) underwent RIRS, 7 (12.7%) received medical treatment in the form of Urolyt-U, and 12 (21.8%) had no further interventions. The cumulative SFR after ancillary procedures was 82.0%.

All expected risk factors were analyzed to determine the independent predictors of stone-free status post-PCNL.

Univariate logistic regression analysis revealed that ischemic heart disease (p=0.009), stone diameter >4 cm (p<0.001), stone density >900 HU (p<0.001), radiolucent stone, complete staghorn stone (p<0.001), upper calyceal stone (p<0.001), middle calyceal stone (p<0.001), and surgeon experience <8 years (p=0.038) were found to be a significant factors affecting the stone-free status.

We carried out a multivariate logistic regression analysis to better define those factors that independently affect stone-free status. Except for stone radio-opacity, which had a high association with stone radiodensity, all significant factors in univariate analysis have been put into the multiple regression model. The multivariate analysis showed that the ischemic heart disease (p=0.033), stone diameter >4.5 cm (p<0.001), stone density >900 HU (p=0.005), and complete staghorn stone (p=0.002) were the independent factors inversely affect the stone-free status.

The findings of the univariate and multivariate logistic regression analyses are summarized in (Tables 1 and 2).

	B coefficient	OR	95% CI of OR	p-value
Age >45 years	0.456	1.578	0.877-2.842	0.128
Obesity	0.276	1.318	0.674-2.579	0.420
Diabetes mellitus	-0.114	0.892	0.388-2.054	0.789
Hypertension	-0.276	0.759	0.311-1.852	0.544
Ischemic heart disease	-1.498	0.223	0.073-0.683	0.009
Chronic liver disease	-0.331	0.718	0.324-1.592	0.415
Preoperative creatinine	-0.732	0.481	0.170-1.362	0.168
Preoperative hemoglobin	-0.085	0.918	0.737-1.144	0.448
Prior ESWL	20.569	--	--	0.999
Prior PCNL	0.970	2.638	0.562-12.388	0.219
Prior renal open stone surgery	-0.623	0.536	0.197-1.457	0.222
Prior renal reconstructive surgery	-1.401	0.246	0.022-2.765	0.256
Hydronephrosis	-0.072	0.930	0.521-1.660	0.806
Renal atrophy	-1.011	0.364	0.079-1.673	0.194
Thin renal parenchyma	1.298	3.662	0.441-30.375	0.229
Solitary kidney	-0.413	0.662	0.144-3.043	0.596
Stone diameter >4.5 cm	-1.185	0.306	0.167-0.558	<0.001
Stone density >900 HU	-1.251	0.286	1.155-0.528	<0.001
Radio-opaque stone	-1.801	0.165	0.062-0.439	<0.001
Complete staghorn stone	-2.745	0.064	0.021-0.196	<0.001
Upper calyceal stone	-1.228	0.293	0.157-0.547	<0.001
Middle calyceal stone	-1.207	0.299	0.164-0.574	<0.001
Lower calyceal stone	0.117	1.124	0.613-2.059	0.705
Acute dilatation	0.093	1.097	0.547-2.200	0.794
Supracostal access	-0.520	0.594	0.276-1.281	0.184
Upper calyceal access	-0.646	0.524	0.271-1.013	0.055
Lower calyceal access	0.301	1.351	0.744-2.455	0.323
Middle calyceal access	-0.504	0.604	0.330-1.106	0.102
Surgeon experience <8 years	0.672	1.959	1.037-3.701	0.038

Table 1: Univariate analysis of the predictors correlated with stone-free status.
(Ag, stone diameter and stone density were categorized according to the median.--, not computed).

	B coefficient	OR	95% CI of OR	p-value
Ischemic heart disease	-1.532	0.216	0.053-0.884	0.033
Stone diameter >4.5 cm	-1.449	0.235	0.106-0.523	<0.001
Stone density >900 HU	-1.123	0.325	0.148-0.715	0.005
Complete staghorn stone	-2.556	0.078	0.016-0.382	0.002
Upper calyceal stone	0.120	1.127	0.444-2.866	0.801
Middle calyceal stone	-0.206	0.814	0.363-1.823	0.617
Surgeon experience <8 years	0.083	1.086	0.479-2.466	0.843

Table 2: Multivariate analysis of the predictors correlated with stone-free status.

DISCUSSION

The aim of treating staghorn calculi is to remove the stones completely and with as little morbidity as possible.[11] PCNL in patients having staghorn calculi remains a procedural difficulty, necessitating the surgeon to execute full stone removal while minimizing morbidity.[12]

According to reports, the stone-free rate following PCNL monotherapy for staghorn calculi ranges from 49 to 78%. [12] In this research, the stone-free rate following PCNL monotherapy was 66.5%. This seems to be greater than the stone-free rate recorded by Al-Kohlany et al.[13] (49%), as they only evaluated and managed entire staghorn calculi, but in this research we included patients having both partial and complete staghorn calculi as well as drew no differentiation between the two. Our study's stone-free rate was likewise greater than that of El-Nahas et al.[14] (56.6%) and Desai et al.[15] (56.9 %). They had topic criteria that were comparable to ours, such as complete and partial staghorn calculi. Our study's stone-free rate was, however, lower than that of Soucy et al., who found a greater stone-free rate (78%). That research included branched stones in only one calyx (borderline staghorn calculi) discovered in 67% of their sufferers, resulting in a lower burden stone and a simpler treatment for the majority of sufferers.[12]

When considering and comparing different procedural approaches, the duration of the surgery is a crucial issue to consider [16], because the length of anesthesia and the risk of postoperative pulmonary complications can have an indirect impact on surgical outputs (amount of blood lost, drop in hemoglobin, and blood transfusion needs) and PCNL complications.[17]

In this study, the average surgical time was 162.60±27.88 (median: 150.00; range: 95.00 to 220.00 min.). Huang et al.[18] found that the average operation duration was 63.5±11.8 min, with a range of 29–103 mins. The length of the surgery was reduced in that study because Huang et al. did not employ a ureteral catheter or balloon catheter prior to PCNL.

A large-scale study found that PCNL can cause severe morbidity or even fatality. According to the AUA guidelines for kidney stone treatment, staghorn calculi have a 7–27% complication rate and an 18% transfusion rate.[19] Previous research found that blood transfusion was required in 14–24% of PCNL with staghorn calculi, based on the surgical technique, patient population, transfusion indications, and the surgeon's decision to perform transfusion .[20]

According to El-Nahas et al.[21], staghorn calculi are a risk factor for severe hemorrhage in PCNL.

Our study found that the number of hemorrhage complications requiring transfusion was lower than previously documented.

In our study the most common intraoperative complication was bleeding (8.7%), followed by pelvic perforation (3.4%) and colon injury was reported in 3 cases (1.5%).

Only 11 patients (5.3%) needed blood transfusion with a median number of 1.00 unit.

El-Nahas et al.[22] founded a link between stone burden (partial and complete staghorn calculi) and stone-free rate in secondary calyx stones. In our research, we distinguished between complete and incomplete or partial staghorn calculi, and we divided the stone burden category into two groups, the first of which was > 4.5 cm and the second of which was < 4.5cm. According to our multivariate analysis, the stone burden > 4.5 cm was connected with the stone-free rate (OR 0.235; 95% CI 0.106-0.523; p <0.001), as did the complete staghorn calculi (OR0.078; 95% CI 0.016-0.382; p <0.002).

We did not use S.T.O.N.E nephrolithometry in our research, which has been shown to be a good predictor of stone-free rates following PCNL for staghorn stones.[23]

The presence of an ipsilateral renal stone open operation or PCNL has been shown to have no statistically significant relationship with stone-free rate in this research. This is similar to a prior study performed by Kurtulus et al.[24]

In our study, we found ischemic heart disease (P 0.033) was an independent factor inversely affecting the stone-free state. This may be interpreted as a restricted time of operation due to high cardiac risk.

In our study, we found stone density >900 HU (p=0.005) was an independent factor inversely affecting the stone-free state. This may be understood by the stones with a density higher than 900 being harder stones that would be difficult to fragment.

The low metabolic assessment of patients in our research is a drawback since analysis of stones and metabolic testing aren't performed frequently on all patients. The study's lack of follow-up information on secondary therapies (like ESWL, ureterorenoscopy (URS), and secondary PCNL) is also a flaw because those data might be used to evaluate the efficacy of combination treatments using ESWL, secondary PCNL efficacy rate, as well as other treatments.

CONCLUSION

PCNL has a very low rate of significant complications and a high rate of success for treating staghorn stones. Ischemic heart disease, stone diameter >4.5 , stone density >900 HU , and complete staghorn stone were the independent factors inversely affect the stone-free status.

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