Original Article

Factors affecting stone clearance in Percutaneous Nephrolithotomy

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Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) is the treatment of choice for large and complex renal stones. It is of paramount importance to deliver the maximum clearance with minimal morbidity. There are different anatomical, stone-related and patient-related factors affecting the stone-free rate. This study is conducted to delineate the factors predicting stone clearance in PCNL.

Methods: A prospectively maintained database of 114 cases, who underwent PCNL between January to October 2016 in Tribhuvan University Teaching Hospital, was analysed. Age, gender, body mass index, surgical and medical history, renal anomalies, American Society of Anesthesiologists score, tract size, type of tract dilatation, fluoroscopy time, stone density, stone location and burden, skin to stone distance, presence of hydronephrosis, and duration of surgery were correlated with the stone clearance. Stone clearance was evaluated with either X-ray or ultrasound of the kidneys, ureters and bladder up to three months of PCNL.

Result: Stone clearance rate was 85.96%. Stone burden($p<0.001$), stone location($p=0.03$), number of calyces involved by stone($p<0.001$) and presence of hydronephrosis($p=0.005$) were statistically different between stone-free and stone-residue group. Multifactorial analysis showed that stone burden, location and no. of calyces involved by stone were the only factors effecting stone free rate. Area under curve for the stone burden was 0.842 ($p<0.001$).

Conclusion: Stone burden, location and number of calyces involved by the stone are the principal factors determining the stone clearance in PCNL.

Keywords: Percutaneous Nephrolithotomy, Renal calculi, Stone clearance

Introduction

Percutaneous Nephrolithotomy (PCNL) is the treatment of choice for large and complex renal stones.[1,2] With increased prevalence of renal stone disease, the number of PCNL is also increasing.[3]. It is of paramount importance to deliver the maximum stone clearance with minimal morbidity.[3] There are different anatomical, stone-related and patient-related factors affecting the stone-free rate (SFR).[4,5] This study is conducted to delineate different factors affecting SFR in PCNL.

Methods

From January to October 2016, a prospectively maintained database of 114 PCNL, which were performed in Tribhuvan University Teaching Hospital, was studied. The number of PCNL performed annually in TUTH is 170 on average and all PCNL included were performed by experienced consultant urologists. All patients with age more than 15 years were included in the study. Approval was obtained from Institutional Review board and consent was collected from all participants. All patients underwent CT KUB/urography preoperatively. Coagulopathy was ruled out and negative urine culture was confirmed. The variables studied were: age, gender, body mass index(BMI), surgical medical history, renal anomalies, American Society of Anesthesiologists(ASA) score, tract size, type of tract dilatation, fluoroscopy time, stone density(Hounsfield unit), stone location and burden, skin to stone distance, presence of hydronephrosis, number of dilated tracts and SFR. Stone burden was calculated in mm^2 using the formula- $\Sigma(0.785 \text{ X } length_{max} \text{ X } width_{max})$ as stated by Tiselius et al[6]. Staghornstone was defined as the stone occupying renal pelvis and two or more calyces[7]. All PCNL were performed under general anaesthesia in prone position with ureteric catheter for retrograde pyelogram. Under fluoroscopic control, puncture was made through the calyx from which maximum burden of the stone could be cleared. Tract was dilated using either multiple metallic telescopic dilatation or single shot dilatation upto the required size of Amplatz sheath. This was 16 F for mini-PCNL and 30 F for standard PCNL. At the end of the procedure, stone clearance was confirmed using fluoroscopy or flexible nephroscope if required. Stone-free status was determined by X-Ray KUB(kidneys, ureters and bladder) for radiopaque stones or ultrasound KUB for radiolucent stones or both immediate postoperatively, at 1 month and 3 months if residual stones were still present. Stone clearance was defined as absence of residual fragments or the presence of residual fragments less than 4 mm which were asymptomatic, noninfectious and nonobstructive.

Continuous data were analysed using Student's t test if there was normal distribution or Mann- Whitney U test if distribution was not normal. Chi-square test was used to analyse categorical data. Multilogistic regression was used to determine the relationship between variables and stone free status. Stone burden and stone density werecorrelated with stone clearance using Receiver's operating curve(ROC). The statistical analysis was performed with the Statistical Package for Social Sciences, version 21.0 (SPSS, Chicago,IL) considering p value<0.05 to be significant.

Results

A total of 114 PCNL met the inclusion critera. Stone clearance rate was 85.96%. The patient and stone characteristics between stone-free group and residual stone group are enlisted in Table1. Stone burden, number of stones, stone location, number of calyces involved and presence of hydronephrosis were statistically different between stone-free and stone-residue group. Similarly, total fluoroscopy time, number of tracts to clear stone and duration of surgery were also different between two groups. Age, sex, side of the surgery, BMI, past history of intervention for stone, presence of chronic kidney disease or other comorbidities, ASA grade, tract size, type of tract dilatation, presence of anatomic abnormalities, skin to stone distance and type of tract dilatation did not affect the stone clearance. Table 2 depicts the multifactorial analysis of the variables affecting SFR. Stone burden, location of stones and number of calyces involved by the stone were statistically significant. Area under the curve (AUC) was 0.842 for stone burden(p<0.001) as shown by Table 3. Figure 1 shows the ROC curve for stone burden and stone density.

Table1. Baseline Characteristics of Study patients in stone-free and stone-residue group

Variable, total (%)	Stone free	Residual stone	P-value
Age (38±13.3years)	38.1±13.3	37.63 ± 13.3	0.897
Male, 65(57%) Female, 49(43%)	55 (48.2%) 43 (37.7%)	10(8.8%) 6(5.3%)	0.787
Left, 55(48.2%) Right, 59(51.8%)	47 (41.3%) 51 (44.7%)	8 (7%) 8 (7%)	0.546
BMI (23.6± 3.05kg/m^2)	23.67 ± 3.05	23.42 ± 2.8	0.750
Stone burden(538±411 mm^2)	441.7± 290	1130.69± 541	<.001*
Past intervention Open surgery PCNL ESWL	 10(8.8%) 7(6.1%) 3(2.6%)	 1(0.9%) 1(0.9%) 0	0.698
Comorbidities CKD(GFR<30 ml/min) Diabetes Mellitus HTN MI Solitary kidney	 10(8.8%) 8(7%) 10(8.8%) 1(0.9%) 2(1.8%)	 1(0.9%) 1(0.9%) 0 0 0	0.679
Standard PCNL Mini PCNL	78(68.4%) 20(17.5%)	13(11.4%) 3(2.6%)	0.53
Type of Dilatation Single shot Telescopic	 30(26.3%) 68(78.9%)	 7(6.1%) 9(7.9%)	0.388
Anatomic abnormalities Horseshoe Diverticular stones Duplex system Malrotated kidneys	 1(0.9%) 3(2.6%) 1(0.9%) 3(2.6%)	 1(0.9%) 1(0.9%) 0 0	0.267
Skin to stone distance <=10cm >10cm	 79(69.3%) 19(16.67%)	 15(13.2%) 1(0.96%)	0.298
Fluoroscopy time(314± 116sec)	295.9± 104	430± 120	<.001*
Duration of surgery(77.4± 20min)	73.4± 14	101.88± 18.96	<.001*
ASA Class 1 ASA Class 2 ASA Class 3	77(67.5%) 20(17.5%) 1(0.9%)	14(12.2%) 1(0.96%) 1(0.9%)	0.151
No of Tracts 1 2	93(81.6%) 5(4.4%)	10(8.8%) 6(5.3%)	0.001*
Stone density(1029±277 HU)	1037.5±282	979±242	0.574
Number of calyces involved by stone Single Multiple Partial staghorn Complete Staghorn	 50(48.2%) 38(33.3%) 10(8.8%) 0	 2(1.8%) 3(2.6%) 5(4.4%) 6(5.3%)	<0.001*
Hydronephrosis No Hydronephrosis	55(48.2%) 43(37.7%)	3(2.6%) 13(11.4%)	0.005*
Stone Location Upper calyx Middle calyx Lower calyx Pelvis Multiple Diverticulum	 13(11.4%) 2(1.8%) 9(7.9%) 26(22.8%) 44(3.9%) 3	 0 0 2(1.8%) 0 14(12.3%) 1	0.03*

*p value-significant

Table 2. Multilogistic regression comparing all factors affecting stone clearance

Characteristics	p-value	Odds Ratio
Age	0.671	1.025
Sex	0.070	0.031
Comorbidities	0.196	0.015
Past surgical history	0.439	0.398
BMI	0.935	1.020
Abnormal anatomy	0.929	0.720
Skin to stone distance	0.295	0.069
Hydronephrosis	0.564	0.420
Number of calyces	0.045*	23.208
Stone burden	0.049*	3.05
Stone location	0.048*	3.142
Stone density	0.235	0.996
ASA	0.828	2.255
Dilatation	0.082	0.070
Side	0.821	0.754

*p-value-significant

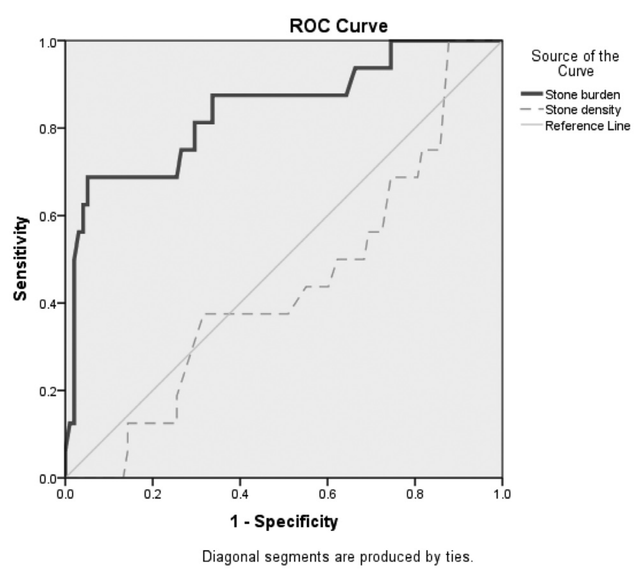

Figure1. Receiver's Operating Characteristic Curve for Stone Burden and Stone Density correlated with Stone Clearance

Table 3.Area under the Curve for Stone burden and Stone density

Variable(s)	Area	Std. Error	p-value	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Stone burden	0.842	0.060	<.001*	0.723	0.960
Stone density(HU)	0.439	0.075	0.436	0.292	0.587

*p-value-significant

Discussion

PCNL is the standard treatment for large and/or complex renal stones.[1] The principal objective of PCNL is absolute clearance of stone with minimum complication. There are different factors related to renal anatomy, stone and patient characteristics affecting the stone clearance.

PCNL is an effective modality for renal stone with overall stone free rates between 49-78% and even higher.[3,8] In our study, SFR was higher than other studies. Labadie et al reported their stone clearance rate to be 56 %.[9] Similarly, Mandal et al had 76.1% SFR in their study.[10] The burden of staghorn stones in studies by Labadie et al and Mandal et al. was 48% and 24% respectively. El-Nahas and his colleague *s*underlined the importance of stone burden in stone clearance after PCNL in their study.[11] Another study by Labadie et al found stone burden to be significant factor affecting SFR with AUC of 0.668. Smith et al reported stone burden, stone location, staghorn stone, stone location and stone count to be the determining factors for the stone clearance.[12] Similarly, Okhunov et al. concluded that stone size and number of calyces involved by the stone were strongly related to SFR.[13] Similar to these studies, our study demonstrated the significant effect of stone burden, stone location, increasing number of involved calyces, multiplicity of stone and staghorn stones in stone clearance after PCNL. These factors add up the complexity of renal stones making them require multiple access and flexible nephroscopy increasing the overall surgery and fluoroscopy time. Staghorn stones comprised of 18.4% of the total stone burden in our study and this may be the reason for higher SFR compared to other studies. Other probable reasons for higher SFR are use of intraoperative flexible nephroscopy, use of miniaturized instruments creating multiple tracts and use of X-Ray KUB for follow up of stone clearance.[14,15]

Our study did not show the association between stone density and stone clearance. Multiple other studies have shown the same results.[13,16] Anastasiadis and colleagues stated that the presence of low-density and very high-density stones is associated with lower stone clearance in PCNL.[17] As stone is a heterogenous mixture having different compositions, there is difficulty in calculating the exact Hounsfield (HU) of the stone. There is no standardised technique to measure HU of the stone.[18] Some accept average value, while others may take the maximum observed value after 'eyeballing' density values by movement of the cursor over the calculus.[18]

Karalar et al found significant association between the presence of hydronephrosis and stone clearance.[13] But another study by Okhunov et al did not show hydronephrosis as the determining factor. Though hydronephrosis was present in the group with residual stone significantly, multilogistic regression did not show significant association. The reason may be that the stone burden may be indirectly reflected by the hydronephrosis which increases as the stone burden increases.

Our study did not show correlation between BMI and stone free rate. Many other studies reported SFR to be independent of BMI.[19,20,21] On the other hand, Fuller and his colleagues in their study of 5803 patients found a significantly inferior SFR and a higher re-intervention rate in higher BMI group.[22] Similar to our study, many studies did not report any association between skin to stone distance and the stone clearance.[23]

Unlike study reported by Smith et al, this study did not find the association between previous history of intervention for stone and stone clearance. Atmoko et al also found significant correlation between previous stone surgery and SFR stating the reasons for decreased stone clearance being infundibular stenosis, anatomic positional differences of the kidney and perinephric fibrosis.[24] But, many studies showed that previous open stone surgery has no impact in SFR.[25]

Though technically challenging, PCNL has been found to be an effective means to clear stones in anomalous kidney and pelvicalyceal system. Prakash and his colleagues in their study of 91 anomalous kidneys have reported SFR of 82% which is comparable to available literatures.[26,27] Though small cohort, renal anomalies did not affect the stone clearance rate in our study.

Many studies did not show association between comorbidities and stone-free rate.[28,29] Similarly, tract size and methods of tract dilatation have no effect in stone clearance. [30,31,32]

The major limitation of the study was that CT KUB was not used to determine stone clearance after PCNL. The use of CTKUB for routine follow-up after PCNL was not pragmatic in our scenario. A large sample size is still needed to determine the effect of some variables like renal anomalies and comorbidities in stone clearance after PCNL.

Conclusion

Stone burden, location and number of calyces involved by the stone are the paramount factors determining the stone clearance in PCNL.

Conflict of Interest: None declared

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