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FACTORS PREDICTING THE SUCCESS OF STANDARD PERCUTANEOUS NEPHROLITHOTOMY: A CLOSE LOOK AT THE STATUS OF PARENCHYMAL THICKNESS AND STONE OPACITY

STANDART PERKUTAN NEFROLİTOTOMİ BAŞARISINI PREDİKTE EDEN FAKTÖRLER: PARENKİMAL KALINLIK VE TAŞ OPAKLIK DURUMUNA YAKIN BİR BAKIŞ

Ümit YILDIRIM[1] Mehmet USLU[1] Mehmet EZER[1]
Bumin ÖRS[2] Cengiz KARA[1]

[1] Kafkas University, School Of Medicine, Department Of Urology, Kars, Turkey
[2] Özel Sağlık Hospital, Department of Urology, İzmir, Turkey

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SUMMARY

Introduction: *The purpose of this study is to find potential variables, especially parenchymal thickness and stone opacity status, that might be useful in predicting percutaneous nephrolithotomy (PCNL)'s stone-free rates.*

Material and Method: *In our clinic, we analyzed retrospective data from July 2014 to May 2022 on patients who underwent PCNL treatment for kidney stones. We applied exclusion criteria and arrived at a sample size of 304 patients. Patients were divided into two groups: those with residual stones and those without. Stone-free individuals (Group F, n=193) were set apart from those with some remaining stones (Group R, n=111). Demographics, stone characteristics, patient characteristics, and surgical outcomes were all compared between the two groups.*

Results: *In Group F, the average stone size was smaller (24,42±8,47 vs. 28,37±11,23, p=0,003). Group R was also higher in terms of stone surface area (295,25±191,74 versus 414,87±312,23, p<0,001). In addition, the opacity features of the stones differed significantly between the two groups (Non-opaque, Group F 25,9% vs. Group R 38,7%, p=0,014), and multi-calyceal stones were more prevalent in Group R (15,5% vs. 27,7%, p=0,008). Hydronephrosis was substantially more prevalent in Group R (72,5% vs. 82.0%, p=0,042), while pretreatment creatine levels were comparable (0,92±0,26 vs. 0,95±0,34, p=0,105). Significantly lower parenchymal thickness was seen in Group R (19,57±4,61 vs. 18,11±4,61, p=0,013). In our multivariate model, renal parenchymal thickness (OR:0,936, 95% confidence interval [CI]: 0,885-0,989; p=0,019) and stone opacity status (OR:0,562, 95% confidence interval [CI]: 0,331-0,955; p=0,033) emerged as independent predictors for residual fragments.*

Conclusion: *The detection and treatment of stones that remain after PCNL are of the utmost importance. Patients with thicker renal parenchyma and opaque stones tend to have a better prognosis regarding stone free-rates after PCNL treatment. This should be considered when conducting the clinical evaluation of patients who will be having PCNL.*

ÖZ

Giriş: *Bu çalışmanın amacı, perkütan nefroitotomi (PCNL) sonrasındaki taşsılığı öngörmede faydalı olabilecek, özellikle parankim kalınlığı ve taş opaklığı durumu gibi potansiyel değişkenleri bulmaktır.*

Gereç ve yöntem: *Kliniğimizde böbrek taşı nedeniyle PCNL tedavisi uygulanan hastaların Temmuz 2014 ile Mayıs 2022 arasındaki geriye dönük verilerini analiz ettik. Dışlama kriterlerini uyguladıktan sonra 304 hastadan oluşan bir örneklem büyüklüğüne ulaştık. Hastalar rezidü taşı olanlar ve olmayanlar olarak iki gruba ayrıldı. Hastalar, stone -free olanlar (Grup F, n=193) ve residual fragman kalanlar olarak (Grup R, n=111) ikiye ayrıldı. Demografi, taş özellikleri, hasta özellikleri ve cerrahi sonuçların tümü iki grup arasında karşılaştırıldı.*

Bulgular: *Grup F'de ortalama taş boyutu daha küçüktü (24,42±8,47 vs 28,37±11,23, p=0,003). Grup R taş yüzey alanı açısından da daha yüksekti (295,25±191,74 vs 414,87±312,23, p<0,001). Ek olarak, taşların opaklık özellikleri iki grup arasında anlamlı olarak farklıydı (Opak olmayan, Grup F %25,9'a karşı Grup R %38,7, p=0,014) ve çoklu kaliks taşları Grup R'de daha yaygındı. (%15,5 vs %27,7, p=0,008). Hidronefroz Grup R'de önemli ölçüde daha yaygındı (%72,5 vs %82,0, p=0,042), tedavi öncesi kreatin seviyeleri karşılaştırılabilirdi (0,92±0,26 vs 0,95±0,34, p=0,105)). Grup R'de anlamlı olarak daha düşük parankim kalınlığı görüldü (19,57±4,61 vs. 18,11±4,61, p=0,013). Çok değişkenli modelimizde böbrek parankim kalınlığı (OR:0,936, %95 güven aralığı [CI]: 0,885-0,989; p=0,019) ve taş opaklığı durumu (OR:0,562, %95 güven aralığında [CI]: 0,331-0,955; p=0,033) residual fragmanlar için bağımsız öngörücüler olarak ortaya çıktı.*

Sonuç: *PNL sonrası kalan taşların tespiti ve tedavisi son derece önemlidir. Daha kalın böbrek parankimi ve opak taşları olan hastalar, PCNL tedavisinden sonra taşslık oranları açısından daha iyi prognoza sahip olma eğilimindedir. PCNL olacak hastaların klinik değerlendirmesi yapılırken bu dikkate alınmalıdır.*

INTRODUCTION

During the past thirty years, the surgical intervention of urinary stones has experienced significant changes as a result of advancements in surgical equipment and endoscopic technology. These advancements have enabled surgeons to more extract urinary stones (1). Minimally invasive methods such as extracorporeal shock wave lithotripsy (ESWL), flexible ureteroscopy (fURS), and percutaneous lithotripsy (PCNL) have essentially replaced open surgery because to the fact that these minimally invasive procedures are both very safe and very effective (2). For the treatment of large stones (>20 mm) in the upper urinary system, a minimally invasive procedure called PCNL has been shown to have a considerably higher stone-free rate (SFR) than traditional methods. According to the guidelines for the treatment of urolithiasis that were developed by the European Association of Urology (EAU), PCNL is still recommended as the treatment of choice for stones that are larger than 20 millimeters (3).

The overall success rate of PCNL's projects ranges from 56 to 96 percent, depending on the series (4-7). The degree of hydronephrosis, the position and size of the stones, the number of stones that are present, as well as the skill level of the surgeon all have a role in determining the likelihood of successful treatment. Predicting whether or not PCNL will be successful can be done using a variety of scoring methods, such as the Guy's stone score and the S.T.O.N.E nephrolithometry technique (8). Despite the fact that studies have been conducted regarding the impact of renal parenchymal thickness and stone opacity status on the success of PCNL, these studies have been and continue to be restricted.

Patients who have had PCNL consistently indicate that coping with remaining fragments is a "headache" that lowers their quality of life and often necessitates additional intervention, which increases the total cost to the healthcare system (9). As a result, being able to accurately forecast whether or not PCNL will be successful prior to the operation is essential for effectively managing the expectations of both patients and surgeons. This study's main objective was to find predictors of PCNL's stone-free rates.

MATERIALS AND METHOD

The study adhered strictly to the guidelines laid out in the Helsinki declaration about research ethics. The institute's ethics review board approved the research undertaking (Approval Number: 80576354-050-99/167). Between July 2014 and May 2022, we analyzed the medical records of patients who had undergone PCNL treatment for kidney stones at our clinic retrospectively. Patients having malrotated kidneys, ptosis, horseshoe kidneys, or multi-calyceal access were not included. 304 patients' records might be obtained in this way.

Each patient underwent a preoperative radiological evaluation consisting of non-contrast computed tomography (NCCT) and kidney-ureter-bladder graphy (KUB). Maximum axial segment thickness was utilized to determine renal parenchymal thickness (PT). All of the operations were performed while the patient was in general anesthesia. After inserting the ureteral catheter in each patient, they were all positioned in the prone position. The posterior calyx was accessed using C-arm fluoroscopy and an 18-gauge needle after contrast was injected into the renal collecting system through a ureteral catheter. For each procedure, a dilation of the tract was performed with Amplatz dilators as large as 30 Fr. After the Amplatz sheath was in the right place, a 26 Fr nephroscope was introduced into the collecting system (Storz Medical AG, Kreuzlingen, Switzerland). The stones was disintegrated using pneumatics (Vibrolith®, ELMED). Forceps were used to extract the fragments of stones. The procedure concluded with the insertion of a 16 Fr nephrostomy into the renal pelvis, which was left there for three days in the absence of any adverse events. Surgery-related issues were categorized using the Modified Clavien-Dindo Classification.

On the first day after surgery, KUB was performed. On day three after surgery, nephrostomy tubes are usually clamped. Patients without pain had their nephrostomy catheters removed, while those with pain underwent antegrade nephroureterography. After inserting a double-J catheter, the nephrostomy was reversed in patients suffering from ureteral obstructions. NCCT was used to establish a conclusive assessment of stone-free status after three months following surgery. Any residual fragments smaller than 4 mm in diameter were considered stone-free if they did not cause any blockages, pain, or infection. Patients were divided into those who did and did not have residual kidney stones. Stone-free individuals (Group F, n=193) were set apart from those with some remaining stones (Group R, n=111). Several characteristics of both groups were compared, including their ages, the kind of stones they had, the patients they treated, and the outcomes of their surgeries.

SPSS 22.0 was utilized for the statistical analysis (SPSS Inc., Chicago, IL, USA). Means and standard deviations were displayed for the continuous variables. Both the T-test and the Mann-Whitney U-test were used to make comparisons between these variables. The numerical or percentage representations of the categorical variables were used. These variables were compared using the Chi-square test and the Fisher's exact test. Risk variables for residual stones were identified using a binomial logistic regression analysis. The odds ratio (OR) and associated 95% confidence interval were employed to express the importance of the effect (CI). The finding was determined to be statistically significant at the p<0,05 level.

RESULTS

Evaluation of our results revealed the following findings: First of all, no significant difference could be demonstrated in terms of gender and age (47,48±13,98 vs. 46,52±14,88, p=0,268) distribution of all groups. Similarly, the difference in using antiagregants and/or anticoagulants between the groups was insignificant (9,8% vs. 14,4%, p=0,155). Likewise, a similar distribution regarding body mass indexes (28,1±4,57 vs. 27,9±4,48, p=0,784) and the Charlson Comorbidity Index (1,24±1,52 vs. 1,23±1,36, p=0,495) was present in our groups. However, there was a significant difference in terms of stone lateralization (Right Side, 35,1% Group F vs 48,6% Group R, p=0,015), and the mean stone size was found to be smaller in Group F (24,42±8,47 vs.28,37±11,23, p=0,003). Similar to stone size, Group R was also ahead in stone surface area (295,25±191,74 vs. 414,87±314,23, p<0,001). Also, the two groups showed a significant difference in the opacity characteristics of the stones (Non-opaque, Group F 25,9% vs. Group R 38,7%, p=0,014), and multi-calyceal stones were more common in Group R (15,5% vs. 27,9%, p=0,008). While the presence of hydronephrosis was significantly higher in Group R (72,5% vs. 82%, p=0,042), preoperative creatine levels were similar (0,92±0,26 vs. 0,95±0,34, p=0,105). The mean stone density was slightly higher in Group F (1118,81±402,36 vs. 1031,44±398,00, p=0,025) and parenchymal thickness was significantly lower in Group R (19,57±4,61 vs. 18,11±4,61, p=0,013) , according to preoperative radiological findings. Although the methods used for renal puncture did not differ significantly for both groups, the mean operative time (159,95±35,24 vs. 191,01±49,06, p<0,001) was found to be longer in Group R. While the mean hemoglobin decrease was higher in Group R, the difference was not statistically significant (1,93±1,08 vs. 2,17±1,18, p=0,080) and the transfusion rates were similar between the groups (6,7% vs. 9,0%, p=0,306). While there was no discernible difference between the groups in terms of postoperative fever, Group R was higher compared in terms of the length of hospitalization. Patient demographics and laboratory findings of the two groups are given in Table 1. Considering the distribution of complications according to the groups, two patients died in each group due to cardiac causes and pulmonary embolism. Group R had a greater proportion of MCC 3a and higher complications. The distribution of complications by the groups is presented in Table 2.

In our univariate logistic regression analysis evaluation, stone size (OR: 1,043, 1,017-1,169; p=0,001), multi-calyceal location (OR: 2,105, 95% CI: 1.192-3,719; p=0,010), lateralization of stones (right kidney) (OR:1,751, 95% CI: 1,086-2,824; p=0,022), opacity status(non-opaque) (OR:0,553, 95% CI: 0,336-0,911; p=0,020), stone surface area (OR: 1,002, 1,001-1,003; p<0,001) and lastly value of parenchymal thickness (OR:0,934, 95% CI: 0,883-0,983; p=0,026) appeared to be risk factors for stone-free status after RIRS. However, in our multivariate model, renal parenchymal thickness (OR:0,936, 95% CI: 0,885-0,989; p=0,019) and stone opacity status (OR:0,562, 95% CI: 0,331-0,955; p=0,033) appeared as independent predictors for residual fragments. The results of the logistic regression analysis are given in Table 3.

Table 1. Patients' Characteristics and Clinical Findings

		Group F (n=193)		Group R (n:111)		*p*
		Count	% or ±SD	Count	% or ±SD	
Gender	Male	132	68,4%	77	69,4%	0,438
	Female	61	31,6%	34	30,6%	
Age		47,48	±13,98	46,52	±14,88	0,268
Antiagregants / Anticoagulant Use		19	9,8%	16	14,4%	0,155
Charlson Comorbidity Index		1,24	±1,52	1,23	±1,36	0,495
Body Mass Index (kg/m²)		28,1	±4,57	27,9	±4,48	0,784
Lateralization	Right	66	35,1%	54	48,6%	0,015
	Left	122	64,9%	57	51,4%	
Stone Size (mm)		24,42	±8,47	28,37	±11,23	0,003
Presence of Hydronephrosis		140	72,5%	91	82%	0,042
Preoperative Creatine (mg/dL)		0,92	±0,26	0,95	±0,34	0,105
Method of Puncture	Bull's Eye	117	60,6%	56	50,5%	0,055
	Triangulation	76	39,4%	55	49,5%	
Stone Surface Area (mm²)		295,25	±191,74	414,87	±314,23	<0,001
Localization	Single Calyx or Pelvis	163	84,5%	80	72,1%	0,008
	Multicalyxel	30	15,5%	31	27,9%	
Stone Density (Hounsfield Unit)		1118,81	±402,36	887,3	±413,4	0,010
Parenchymal Thickness (mm)		19,57	±4,61	18,11	±4,61	0,013
Opacity Status	Opaque	143	74,1%	68	61,3%	0,014
	Non-Opaque	50	25,9%	43	38,7%	
Operative Time (min)		159,95	±35,24	191,01	±49,06	0,001
Hemoglobin Decrease (g/dL)		1,93	±1,08	2,17	±1,18	0,080
Transfusion		13	6,7%	10	9,0%	0,306
Hospitalization Time (day)		4,33	±1,87	5,40	±4,45	<0,001
Postoperative Fever		9	4,7%	5	4,5%	0,596

Table 2. Distribution Of Complications Among The Groups According To The Modified Clavien Dindo Classification

		Group F (n=193)		Group R (n=111)	
		Count	%	Count	%
MCC	0	140	72,5%	69	62,2%
	1	37	19,2%	27	24,3%
	2	9	4,7%	6	5,4%
	3a	0	0,0%	2	1,8%
	3b	2	1,0%	0	0,0%
	4a	1	0,5%	3	2,7%
	4b	2	1,0%	2	1,8%
	5	2	1,0%	2	1,8%

Table 3. Univariate And Multivariate Logistic Regression Analysis Of The Risk Factors For Residual Fragments During Postoperative 3 Months

	Univariate			Multivariate		
	p	OR	95%CI	*p*	OR	95%CI
Lateralization						
Right	0,022	1,751	1,086-2,824	0,114	1,527	0,903-2,580
Left						
Size	0,001	1,043	1,017-1,069	0,735	1,008	0,962-1,057
Opacity						
Opaque						
Non-opaque	0,020	0,553	0,336-0,911	0,033	0,562	0,331-0,955
Hydronephrosis	0,065	0,581	0,326-1,035			
Localization						
Other						
Multicalyxel	0,010	2,105	1,192-3,719	0,577	0,824	0,417-1,627
Stone Surface Area	<0,001	1,002	1,001-1,003	0,098	1,002	1,000-1,003
Parenchymal Thickness	0,026	0,934	0,883-0,983	0,019	0,936	0,885-0,989
Stone Density (HU)	0,013	0,999	0,999-1,000	0,391	1,000	999-1000

MCC: Modified Clavien-Dindo Classification
HU Hounsfield unit

DISCUSSION

The key finding of this study is that the thickness of the renal parenchyma and the opacity of the stone are independent criteria that predict success following PCNL. Standard PCNL is the standard treatment for large renal stones due to greater stone-free rates than minimally invasive methods and fewer problems than open surgery (10) Fragments are capable of growing or causing symptoms. Larger residual pieces were associated with a higher incidence of stone-related incidents and a quicker time to the occurrence (11). One of the primary objectives of contemporary endourology is to achieve the highest stone-free rates in a single session. Therefore, it is essential to accurately predict the operation's success.

In accordance with the literature, the preoperative stone load in Group R was greater in terms of both stone width and stone surface area (12,13). In these analyses, neither kidney (left or right) was significantly more likely to be stone-free than the other. Our data suggested that the right kidney was more likely to have a significant residual fragment after PCNL. Possible explanations for this finding are discussed below. Since our research was performed in a training clinic, inexperienced surgeons may have tried to alter the right-side access methods to reduce the risk of liver injury. Nonetheless, this circumstance did not emerge as a separate predictor in our multivariate model. When we compared the stone densities of both groups, we found that group F was slightly denser. Our univariate and multivariate analyses, however, revealed that this finding was not important for predicting the stone-free status. In contrast to our findings, previous research has suggested that both extremely high and extremely low stone densities can affect stone-free rates(14). Again, contrary to the studies in the literature, the incidence of preoperative hydronephrosis was higher in Group R than in the other group, close to the statistical significance limit (p=0.042). Both our univariate and multivariate analyses showed that this value did not predict PCNL's success. The literature suggests that stone-free rates are negatively impacted in the absence of preoperative hydronephrosis (15). Multiple stone localization is critical to the success of PCNL, according to studies, and multiple stone localization has a negative impact on stone-free rates(16). The incidence of clinically significant residual fragments was high in patients with multicalyceal stones in our study, which does not contradict this information. However, multicalyceal localization was not identified as an independent predictor in our multivariate model.

Finally, and most importantly, we found that the presence of stone opacity and the thickness of the renal parenchyma were independent predictors of clinically significant residual fragments in our multivariate analysis. Our findings regarding opacity are consistent with previous studies(17). The fact that residual fragments are not reflected in fluoroscopy during the operation may account for the lower success rate seen with non-opaque stones. The impact of renal parenchymal thickness on PCNL success has been studied in the past. Tepeler et al. found that renal parenchymal thickness did not influence PCNL success (18), whereas Karalar et al. discovered that patients with thicker renal parenchyma had a better stone-free outcome following PCNL(19). Results from our study showed that Group F had significantly greater parenchymal thickness rates than the other group. According to reports, PT calculated on NCCT is an effective predictor of relative renal function, and it is useful to distinguish between bilateral renal function based on the variance in renal parenchymal thickness between the two kidneys (20-22). These studies allow us to base our conclusion about PT on the following: greater parenchymal thickness may indicate more nephrons and that means more fragment washout in that renal unit. This can be a possible explanation for the lower PT value we measured in group R.

Our overall stone-free percentage of 63.4% is notable, but it is lower than the values reported in the aforementioned studies (4-7). It is possible that remaining fragments missed by ultrasonography and conventional radiography were uncovered thanks to our clinical regimen for stone-free control using computed tomography. It is possible that surgeons with limited experience in percutaneous nephrolithotomy and endourology will perform the treatment because our clinic serves as a training ground for future medical professionals. To now, we have been unable to collect any relevant information.

Limitations

This study's main restriction is that it was conducted retrospectively. Additionally, the findings could be influenced by the fact that the data came from a single location and that different surgeons with different levels of experience carried out the operations. Another potential limitation is calculating the current stone burden, which uses parenchymal thickness rather than renal parenchyma volume. We applied these computations for their simplicity of usage. With so little information available in the literature about the prognostic role of renal parenchymal thickness in PCNL success, we are certain that our findings will still be useful.

CONCLUSION

The diagnosis and treatment of stones residing after PCNL are of the greatest priority. Patients who have thicker renal parenchyma and stones that are opaque on X-ray appear to have a better prognosis after receiving PCNL treatment. Both of the aforementioned parameters are simple to check before an operation. When conducting the clinical evaluation of patients who will be undergoing PNL, this should be taken into consideration.

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Corresponding Author

Ümit YILDIRIM (Dr. Öğrt. Üyesi)
Kafkas University, School Of Medicine, Department Of Urology, Kars, Turkey,
E-mail: dr.umityildirim87@gmail.com
Phone:+905425584580
ORCID: 0000-0003-3065-9001

Mehmet USLU (Dr. Öğrt. Üyesi) ORCID: 0000-0002-8370-3793
Mehmet EZER (Dr. Öğrt. Üyesi) ORCID: 0000-0003-4422-6768
Bumin ÖRS (Uzm. Dr.) ORCID: 0000-0002-9471-7031
Cengiz KARA (Prof. Dr.) ORCID: 0000-0002-6561-368X