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Perioperative parameters predicting blood transfusion after percutaneousnephrolithotomy

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Abstract

Aim: We aimed to evaluate the perioperative parameters which can effect blood transfusion after percutaneous nephrolithotomy (PCNL).
Material and Methods: Two hundred and seventy patients, who underwent PCNL between January 2017 and June 2020 in Departments of Urology, Nevşehir State Hospital, and Sultan Abdulhamid Han Education and Research Hospital, were evaluated retrospectively. Patients were divided into Groups I and II, according to whether or not blood transfusion was performed after PCNL, and perioperative parameters were compared.
Results: There was no statistically significant difference between Group I and II in terms of age, gender, side of the stone, ipsilateral open stone surgery or PCNL history, presence of renal anatomic anomaly, preoperative hydronephrosis grade, stone size in computed tomography (CT), Hounds field Unit (HU) value, Guy's Stone Score (GSS), skin to stone distance, targeted calyx (upper, middle or lower), number of calyceal access, duration of operation, postoperative D-J insertion rate and postoperative fever ($p > 0.05$). The riskiest period in terms of blood transfusion requirement after PCNL was determined as the first 24th and 76th hours (Relative risk for blood transfusion 26.7 and 105.73, respectively), [AUC = 0.87 (95% CI: 0.785-0.972)].
Conclusion: The only factor affecting blood transfusion after PCNL is the time needed to achieve limpid urine coming out of the nephrostomy. Post-PCNL bleeding coming out of the nephrostomy tube is a valuable parameter in terms of the blood transfusion requirement at the first 24 and 96th hours postoperatively. Close follow-up of the nephrostomy color using objective criteria can be used as a factor that can provide us with additional information in terms of transfusion requirements in addition to the patient's clinic, vital signs, and laboratory tests.

Keywords: PCNL, Postoperative hemorrhage, Post-PCNL transfusion, Nephrolithiasis

Introduction

According to EAU 2020 urolithiasis guidelines, percutaneous nephrolithotomy is the first treatment option recommended for kidney stones larger than 2 centimeters [1]. Multiple and complex stones are mainly treated with this method [2]. Early or late hemorrhage after PCNL is one of the common and serious complications that need attention [3, 4]. At present, 1.2 to 10.8% of patients may need to blood transfusion, after PCNL [3, 5, 7]. Many factors have been reported that increase the risk of transfusion after PCNL. Factors such as renal parenchyma thickness, degree of hydronephrosis, stone size, stone density in Hounsfield Units (HU), diameter of percutaneous access, perforation of renal pelvis, postoperative blood loss are some of these factors [6, 8]. Post-PCNL hemorrhage and blood transfusion requirements are disadvantages in terms of both patient morbidity and cost-effectiveness. Knowing the factors associated with the need for transfusion is important in terms of patient management. Also, the additional challenges that the transfusion procedure will bring to the patient, surgeon, and the health system are important for such a frequently performed surgical method. Previous studies are single-center studies that mainly focused on factors such as postoperative (postop) blood loss rate, factors that may reduce blood loss related to patients, drugs, dilatation type, operation time, and the angioembolization requirement [6, 9-11].

In this two-institutional study; we aimed to examine 17 independent parameters, which may affect the blood transfusion requirement after PCNL, such as patient-dependent factors, stone-related factors, operative technique-related factors, and postoperative factors such as the time taken to achieve limpid urine coming out of the nephrostomy.

Material and Methods

The data of 320 patients who underwent PCNL surgery between 2017-2020, at the urology departments of and Sultan Abdulhamid II Training and Research Hospital and Nevşehir State Hospital were retrospectively scanned and recorded. The ethics committee approval was obtained from the local ethic committee of Nevşehir Hacı Bektaş Veli University (2020.18.264.) and all methods used in the study were carried out according to the Helsinki Declaration principles.

Adult patients, who underwent PCNL operation for kidney stones were included in the study. Patients with solitary kidney and with other additional diseases that may affect the likelihood of postoperative bleeding (e.g. PTZ / INR elevation, throm bocyto penia, severe liver/kidney failure, anticoagulant use, uncontrolled systemic hypertension, hereditary coagulopathies, etc.) were excluded from the study. A total of 320 patients' data were obtained and 270 patients, who met the study criteria were included in the study. Preoperative hemogram, serum biochemistry, prothrombin time (PTZ), international normalized ratio (INR) value, viral serum markers (HIV, HBV, HCV), urine analysis, urine culture, PA Chest X-Ray, and preoperative computed tomography (CT) tests were performed on all patients. Patients' age, gender, stone side, previous PCNL or open stone surgery history, renal anatomic anomaly presence, hydronephrosis grade, the stone size, Houndsfield Unit (HU), Guy's stone score (Figure 1), distance from the skin surface to the stone, targeted calyx (lower, middle or upper), number of calyceal access, surgery time, time take to achieve limpid urine coming out of the nephrostomy tube, D-J stent placement, presence of postoperative fever and need for blood transfusions were recorded.

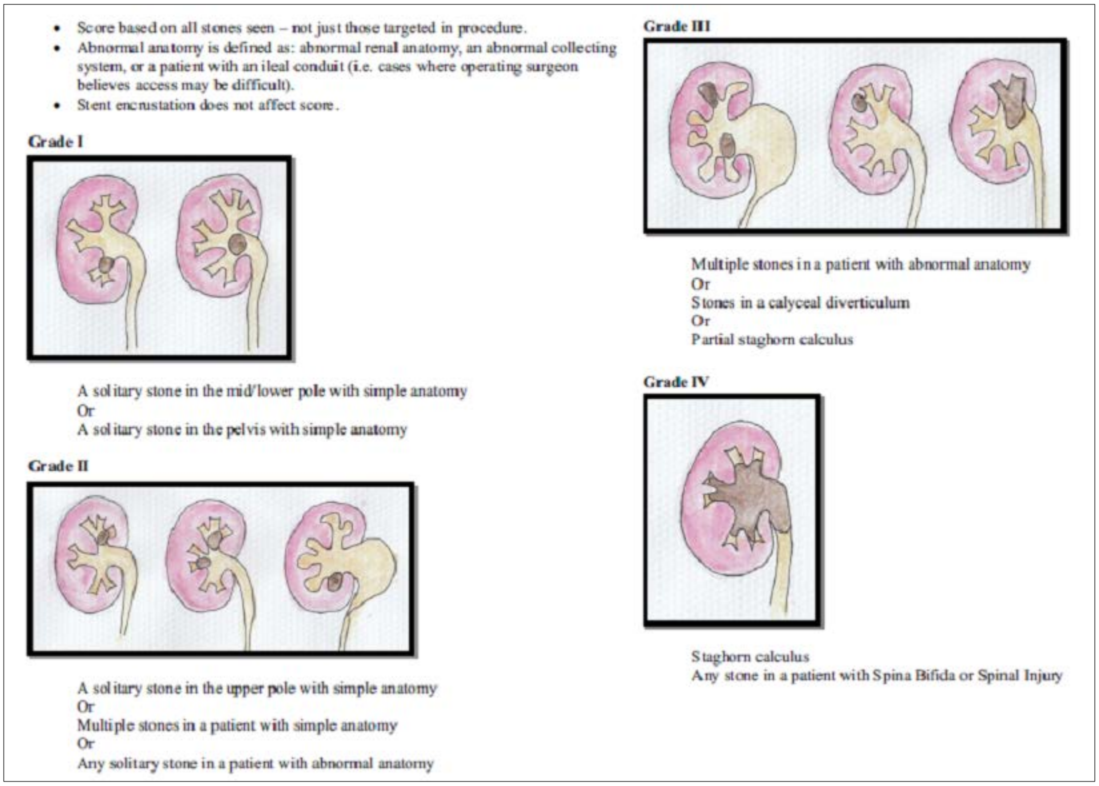

Fig 1: Guy' s Stone Score [12]

All surgeries were performed by experienced surgeons with the same technique. According to this reason, factors related to the surgeon experience that might affect the study results were minimized.

All surgeries were performed in the prone position with triangulation or bull eye technique. Amplatz dilatation was performed up to 30F dilator. Lithotripsy was performed with pneumatic lithotripter. A Malecott catheter was placed through the nephrostomy tract to all patients. J-J catheter insertion was performed if necessary. Operation time was calculated from the cystoscopic entry to the insertion of the nephrostomy tube. Access count was calculated as the total number of all access attempts. Postoperative fever was defined as at least 2 occurrences of ≥38Cº of fever or ≥38Cº degrees persistent fever after the first 24 hours postoperatively. Time taken to achieve clear urine coming out of the nephrostomy tube was the duration until the fluid coming out of the nephrostomy turns to the normal limpid urine color, which was calculated by the surgeons during the visits.

The patients were divided into 2 groups according to the need for postoperative blood transfusion or not. Patients who did not require postoperative transfusion were labeled as Group I, and patients who had a blood transfusion were labeled as Group II. The statistically significant differences between the two groups were investigated.

SPSS (22.0, Chicago, IL, USA) were used for statistical analysis. The distribution of continuous variables was evaluated by the Shapiro Wilk test. Qualitative data were indicated as frequencies and percentages. Statistical evaluation results were reported as median - interquartile range (IQR) according to the normal distribution of variables. Mann-Whitney U-test, Fisher's exact test, Yates Chi-square (Continuity Correction) test and Bonferroni corrections were used to compare the both groups. Binary logistic regression analysis was used to assess the correlation between the postoperative blood transfusion and other parameters. Receiver Operating Characteristic (ROC) analysis was applied to determine the cut-off value of significant parameters. $p < 0.05$ was considered statistically significant in all analyses.

Results

We assessed 270 patients who meet the inclusion criteria. Median age of the patients was 46.00 (35.75-58.00) years. Sixty one patients (22.6%) were female and 209 (77.4%) patients were male. One hundred forty (51.9%) patients' stones were left-sided and 130 (48.1%) patients' were right-sided. Thirty (11.1%)

patients had open surgery history and 39 (14.4%) patients had PCNL history for kidney stone. While there were renal anatomic anomaly in 7 (2.6%) patients, 245(90.7%) patients had normal renal anatomy. The median preoperative hydronephrosis grade was 1 (0-2). The median stone size was 25 (20-35) mm. The median HU was 1200 (1027.50-1354.75). The median Guy's stone score (GSS) was 2 (1-2). The median skin to stone distance was 90 (74.50-105.00) mm. The median operation time was 90 (60-120) min. Superior pole access was performed in 8 (3%) patients, mid-calyx access was performed in 29 (10.7%), Lower calyx access was performed in 233 (86.3%) patients.. The median calyceal access count was 1 (1-1). The median time to achieve clear urine coming out of the nephrostomy was 16 (8-33.25) hours. Fifty (18.5%) patients underwent D-J insertion and 19 (6.5%) patients had fever. Eighteen (6.7%) patients underwent postoperative blood transfusion (Group II).

Two hundred and fifty-two (93.4%) patients were in Group I and 18 (6.6%) included in Group II. Parameters and p values with no statistically significant difference between the two groups are given in Tables (Tables I, II and III). The median time to clear urine from the nephrostomy in the postoperative period was 15 (8-31) hours in Group I and 67.50 (37.75-84) hours in Group II.

Table 1: Descriptive values of quantitative variables in the both Groups.

Variables	Grup I Median (IQR)	Grup II Median (IQR)	P values
Age (Years)	46 (36 - 58)	43 (29.75 – 62.50)	0.686
Preoperative Hydronephrosis Grade	1 (0 - 2)	0 (0 - 2)	0.546
Stone Size (mm)	25 (20 - 35)	30 (21.5 - 37.5)	0.142
Houndsfield Unit	1210 (1005 – 1358.25)	1166 (1100 – 1362.5)	0.943
Guy's Stone Score	2 (1 - 2)	1.5 (1 – 2.25)	0.934
Skin to Stone Distance (mm)	90 (75.25 - 105)	81.5 (59.25 - 101.25)	0.088
Number Of Calycial Access	1 (1 - 1)	1 (1 - 1)	0.997
Duration of Surgery (Min.)	90 (60 – 119.5)	97.5 (68.75 – 120.5)	0.298
Nephrostomy Fluid Clarification Time (Hours)	15 (8 - 31)	67.5 (37.75 - 84)	<0.001

Table 2: Qualitative variables in the both Groups.

		Group I n (%)	Group II n (%)	Total n (%)	P values
Gender	Female	58 (21.5 %)	3 (1.1 %)	61 (22.6 %)	0.771
	Male	194 (71.9 %)	15 (5.6 %)	209 (77.4 %)	
Side	Left	133 (49.3 %)	7 (2.6 %)	140 (51.9 %)	0.371
	Right	119 (44.1 %)	11 (4.1 %)	130 (48.1 %)	
Ipsılateral Open Stone Surgery	No	225 (83.3%)	15 (5.6 %)	240 (88.9 %)	0.433
	Yes	27 (10.0%)	3 (1.1 %)	30 (11.1 %)	
Ipsılateral PCNL History	No	216 (80.0 %)	15 (5.6 %)	231 (85.6 %)	0.731
	Yes	36 (13.3 %)	3 (1.1 %)	39 (14.4 %)	
Renal Anatomic Anomaly	No	245 (90.7 %)	18 (6.7 %)	263 (97.4 %)	1
	Yes	7 (2.2 %)	0 (0.4 %)	7 (2.6 %)	
Postop J-J Insertion	No	207 (76.7 %)	13 (4.8 %)	220 (81.5 %)	0.343
	Yes	45 (16.7 %)	5 (1.9 %)	50 (18.5 %)	
Postoperative Fever	No	236 (87.4 %)	15 (5.6 %)	251 (93.0 %)	0.123
	Yes	16 (5.9 %)	3 (1.1 %)	19 (7.0 %)	

Table 3: Comparison of the both groups in terms of the entered calyx.

	Entered Calyx			Total
	Inferior	Middle	Superior	
Group I n(%)	221 (80.1%) [a]	27 (9.8%) [a]	10 (3.6%) [a]	258 (93.5%)
Group II n(%)	16 (5.8%) [a]	2 (0.7%) [a]	0 (0.0%) [a]	18 (6.5%)
p value	p > 0.05			

Each superscript letter denotes a subset of Entered Calyx categories whose column proportions do not differ significantly from each other at the 0, 05 level. The time taken to achieve limpid urine coming out of the nephrostomy in Group II was found to be statistically significantly higher than the patients in Group I (p <0.05, Table I). In binary logistic regression analysis conducted to evaluate the relationship between blood transfusion requirement and other parameters only the time taken to achieve limpid urine coming out of the nephrostomy was found to statistically significantly increase the postoperative blood transfusion risk. This risk increased by 1.09 times with every one-hour increase in the time to achieve limpid urine coming out of the nephrostomy (p< 0.05), (Table IV).

Table 4: Factors associated with transfusion after PNL (Logistic regression analysis)

	Median (Interquartile Range)	B	S.E.	p	Odds Ratio	95% confidence interval for β
						Lower to upper
Age	46 (37.75 - 58.00)	-0.014	0.025	0.583	0.98	0.93 to 1.03
Gender	-	-0.321	0.925	0.729	0.72	0.11 to 4.44
Side	-	-0.550	0.760	0.469	0.57	0.13 to 2.55
Ipsilateral Open Stone Surgery	-	-0.705	1.070	0.510	0.49	0.06 to 4.02
Ipsilateral PCNL History	-	-1.530	0.908	0.092	0.21	0.03 to 1.28

Renal Anatomical Anomaly	-	18.874	12409.820	0.999	157395977.32	0.00 to 0.00
Preop Hydronephrosis Grade	1.00 (0.00 – 2.00)	-0.098	0.298	0.742	0.90	0.50 to 1.62
CT Stone Size	25 (20.00 - 35.00)	-0.028	0.033	0.394	0.97	0.91 to 1.03
Stone Houndsfield Unit	1200.00 (1027.50-1354.75)	-0.001	0.001	0.397	0.99	0.99 to 1.00
Guy's Stone Score	2.00 (1.00 – 2.00)	-0.138	0.482	0.775	0.87	0.33 to 2.24
Skin to Stone Distance	90.00 (74.50 – 105.00)	-0.028	0.017	0.093	0.97	0.94 to 1.00
Inferior Caliceal Access	-	22.273	10758.052	0.256	4711973542.75	0.00 to 0.00
Middle Caliceal Access	-	18.937	10758.052	0.999	167559207.51	0.00 to 0.00
Superior Caliceal Access	-	-	-	0.998	-	-
Number Of Entered Calyx	-	1.404	1.377	0.308	4.07	0.274 to 60.53
Duration Of Operation	90.00 (60.00-120.00)	-0.014	0.014	0.307	0.98	0.96 to 1.01
Nephrostomy Fluid Clarification Time	16.00 (8.00 – 33.25)	0.092	0.022	<0.001*	1.09	1.05 to 1.14
Postop J-J Insertion	-	0.016	0.929	0.986	1.02	0.16 to 6.28
Postop Fever	-	-1.931	1.045	0.065	0.15	0.02 to 1.13

ROC analysis was performed to calculate Cut-off values of the time taken to achieve limpid urine coming out of the nephrostomy, which is the only statistically significant parameter. When the first 24 hours, which is the riskiest period after PCNL, is evaluated, the time to achieve limpid urine coming out of the nephrostomy tube exceeded 24.5 hours was determined as the riskiest period for postoperative blood transfusion [With high specificity (83%) and moderate sensitivity (68%)]. It was observed that this risk increased 26.70 times at the 24.5th hour. In cases where the time to achieve limpid urine coming out of the nephrostomy tube was prolonged, the 97th hour was determined as the period in which blood transfusion risk was highest with 0.99 specificity and 0.22 sensitivity, and it was observed that this risk increased 105.73 times [AUC = 0.87 (95% CI: 0.785-0.972)]. (Figure 2).

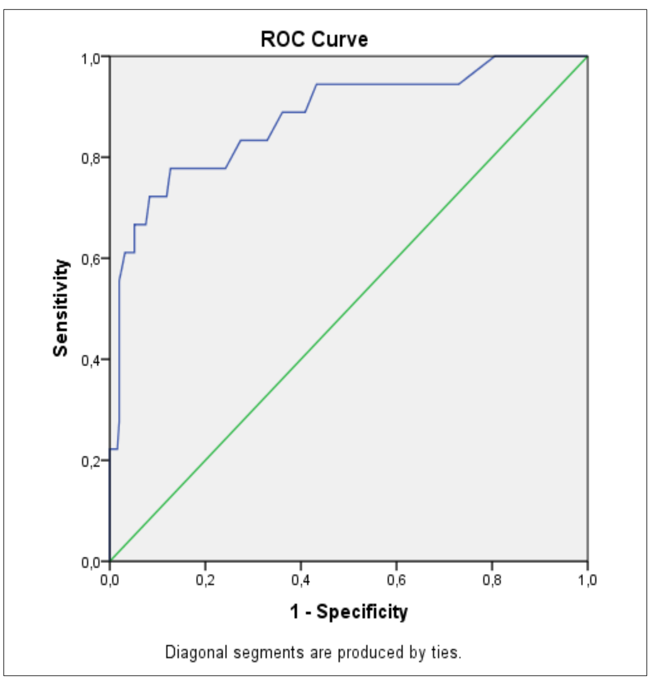

Fig 2: ROC analysis for cut-off values of the duration of achieving limpid urine coming out of the nephrostomy tube.

Area Under Curve (AUC)	Std. Error	Asymptotic Sig.^{b}	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
,878	,048	,000	,785	,972

Discussion

With the impact of developing technology, PCNL has become a surgery that can be performed with fewer complications and higher success rates nowadays. However, it is still associated with potentially life-threatening complications such as postoperative fever, hydrothorax, urinary septicemia, and blood transfusion [13]. Hemorrhage requiring blood transfusion after PCNL is one of the major complications and may cause serious conditions that may require angioembolization [14]. In this two-institutional study; we aimed to investigate 17 independent parameters, which may affect the blood transfusion requirement after PCNL, such as patient-dependent factors, stone-related factors, operative techniques-related factors, and postoperative factors such as time needed to achieve limpid urine coming out of the nephrostomy.

Among the parameters we examined in our study, we found that only the time to achieve limpid urine coming out of the nephrostomy tube was significantly associated with post-PCNL blood transfusion. In a retrospective non-randomized analysis performed by Ketsuwan C. *et al.*; It was stated that there was no statistically significant difference in terms of age, gender, side of the stone, ipsilateral open stone surgery or PCNL history, preoperative hydronephrosis grade, stone Houndsfield Unit (HU) value, the distance of the stone from the skin surface and targeted calyx between the patient groups who had transfused and did not transfuse after PCNL (p>0.05) [15]. Similarly, in our study, there was no statistically significant difference between the transfusion and non-transfusion groups in terms of all these parameters (p>0.05).

Renal anatomical anomaly can be considered as another factor that may affect the possibility of bleeding and transfusion during PCNL. However, previous literature and the results of our study have shown that this is not true. In a study by Khadgi S *et al.*, it was reported that 1.7% of the patients required blood transfusion after PCNL operations performed in 59 patients with renal anatomical anomalies [16]. A study conducted by Sarılar Ö. et. al. reported that the transfusion rate was 5.6% in the standard PCNL group and 1.9% in the mini PCNL group [17]. Previous studies generally reported that the blood transfusion rates after PCNL operations performed in kidneys with anomalies did not differ significantly from the standard PCNL groups, and this rate ranged from 1.7% to 18.3% in all patient groups [16, 18]. In our series, a total of 7 (2.5%) patients had renal anatomical anomalies and none of them required blood transfusion (0%). The transfusion rate in our patients with kidney anomaly was not higher than the normal patients and rates reported in previous studies.

Additionally, in our study, no statistically significant difference was found between the groups with and without blood transfusion in terms of the rate of renal anatomical anomalies (p>0.05). According to results of previous literature and our study; we think that there is no significant relationship between renal anatomical anomaly and post-PCNL blood transfusion.

Ketsuwan *et al* stated that the mean stone size was statistically significantly higher in the blood transfused PCNL group (p<0.05) [15]. However, in another study by Kim H. Y. *et al*; It was reported that in 281 patients who underwent PCNL surgery, there was no statistically significant difference in stone size between the transfusion and non-transfusion groups [19]. In our study, there was no significant difference between the groups in terms of stone size, and our results were similar to the study of Kim H. Y. *et al*. (p>0.05).

In a study where the PCNL operation had been performed with the upper calyx access in 227 cases by Lojanapiwat B. *et al*, it is reported that there is no significant relationship between GSS and blood transfusion [20]. Also, our study results were similar (p>0.05).

In the study which compared patients with multiple and single accesses by Ketsuwan *et al*.; It has been reported that the rate of multiple access was statistically significantly higher in the transfused PCNL group (p<0.05) [15]. In another study by Huang J. *et al*. which performed PCNL operations in patients with complex renal stones, it has been reported that there is no statistically significant difference in terms of postoperative blood transfusion rates between single and multiple access patient groups [21]. In the studies mentioned above, the groups were compared according to performing single or multiple accesses. However, in our study, the groups were compared in detail according to the total numbers of calyceal access, and it was observed that there was no statistically significant difference in the number of accesses between the transfusion and non-transfusion groups (p>0.05). In our study, the numbers of calyceal access in all patients were calculated separately and compared in detail. We believe that our study is superior in this respect.

In a prospective study, in which Syahputra P. A. *et al*. investigated the factors predicting blood loss in PCNL, it was stated that the operation time was not associated with blood loss [21]. In our study, there was no statistically significant difference between the transfusion and non-transfusion groups in terms of the operation time, in a way that supports the study of Syahputra *et al*. (p>0.05), (Table I).

In a randomized controlled study conducted by Bai F *et al*; It was reported that there was no statistically significant difference between the patient groups with and without J-J insertion after PCNL in terms of hemoglobin decrease and blood transfusion [23]. In our study, there was no statistically significant difference in J-J insertion rate between transfusion and non-transfusion groups (p>0.05).

In a retrospective study by Yang T *et al*., it was reported that there was no statistically significant difference in blood transfusion rates between the patient groups with and without fever after PCNL and between the patient groups who developed and did not develop Systemic Inflammatory Response Syndrome (SIRS) after PCNL [24]. In our study, there was no statistically significant difference in fever rates between the transfusion and non-transfusion groups (p>0.05).

In our study, it was observed that the time taken to achieve limpid urine coming out of the nephrostomy tube was statistically significantly higher in the transfusion group (p<0.001). Also, in binary logistic regression analysis in which postoperative transfusion parameter is taken as an independent variable, It was observed that the rate of postoperative blood transfusion increased significantly with the increase in the time taken to achieve limpid urine coming out of the nephrostomy tube (the risk of transfusion increased 1.09 times for every 1 hour), (p<0.001). When we investigated the previous literature, we found that there was no study investigating the effect of the time taken to achieve limpid urine coming out of the nephrostomy tube on blood transfusion.

In our study, we calculated the cut-off values for the blood transfusion requirement of the time to achieve limpid urine coming out of the nephrostomy tube, which is the only statistically significant parameter. When we investigated in terms of acute bleeding, 24.5th hours of the bleeding was determined as the time with the highest blood transfusion risk with 83% specificity and 68% sensitivity, and bleeding that continued until this time increased the blood transfusion risk 26.7 times (p <0.05). When we investigated in terms of chronic bleeding, 96th hour of the bleeding was determined as the time with the highest blood transfusion risk with 99% specificity and 22% sensitivity, and bleeding that continued until this time increased the blood transfusion risk 105,73 times [AUC = 0.87 (95% CI: 0.785-0.972)].

The use of nephrostomy urine color is, unfortunately, a subjective criterion in evaluating the need for blood transfusion after PCNL, and nephrostomy urine color should be evaluated based on objective criteria to determine the need for blood transfusion.

Hematuria grading system was defined in a study by Stout *et al* [25]. This classification can be used to interpret the need for transfusion more clearly in the follow-up of nephrostomy urine color. It is obvious that this grading system and similar objective grading systems will be an objective guide in terms of blood transfusion assessment after PCNL in the years to come.

According to the results of our study, in case of prolonged time needed to achieve limpid urine coming out of the nephrostomy after PCNL; we think that vigilance is needed in terms of blood transfusion at the first 24th and 96th hours. At the end of the 1st and 4th day, which are the most risky times in terms of blood transfusion risk, the need for blood transfusion can be decided with the support of laboratory results and vital signs. With broader studies on this subject, clear values in terms of the time to achieve limpid urine coming out of the nephrostomy can be identified. Also, clearer criteria can be established regarding which patient should be transfused and when, and a more proactive approach can be displayed in cases in which the time to achieve limpid urine coming out of the nephrostomy is prolonged.

Our study has some natural shortcomings due to its retrospective nature. We have not evaluated postoperative decrease in hemoglobin and hematocrit levels and some diseases that may have a potential effect on bleeding such as dyslipidemia, diabetes, and hypertension. While deciding to transfuse patients, we considered the patients' hemoglobin drop under 10 g/dL and the clinical symptoms of hemorrhage (hypotension, tachycardia, nephrostomy bleeding that does not decrease in severity), and in this respect, the risky patients are transfused. For this reason, we thought that investigating the amount of hemoglobin decrease would not provide additional information. Also, in our study, the sum of the longest diameters of the stones, not the stone surface area, was evaluated as the stone size. This can be considered as another disadvantage of our study.

Conclusion

According to the results of our study; the only factor affecting blood transfusion after PCNL is the time to achieve limpid urine coming out of the nephrostomy. Post-PCNL bleeding coming out of the nephrostomy tube is a valuable parameter in terms of the blood transfusion requirement at the first 24 and 96 hours postoperatively. In the postoperative period, close follow-up of the nephrostomy color according to objective criteria can be used as a factor that can provide us with additional benefits in terms of transfusion requirements in addition to the patient's clinic, vital signs, and laboratory tests. More comprehensive and prospective studies are needed to support the results of our retrospectively designed study.

Ethical approval

This prospective descriptive study was approved by the local Ethics Committee of Nevşehir Hacı Bektaş Veli University (2020.18.264.).

Patıentsʾ consent

Informed consents were obtained from patients to publish the data concerning this study.

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