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The relationship between map scores and complications after standard percutaneous nephrolithotomy

Veli Mert Yazar[1*], Osman Gercek[1], Kutay Topal[2], Kemal Ulusoy[1] and Recep Uzun[1]

Abstract

Purpose Upper urinary tract stones are a common condition in urology clinics. Percutaneous nephrolithotomy (PCNL) is an effective procedure frequently used for the treatment of stones larger than 2 cm. MAP scoring is used to predict oncological outcomes and intraoperative complications after partial nephrectomy by using the thickness and adhesion of perinephric adipose tissue. We examined the relationship between MAP score and clinical and demographic findings of the patients, especially postoperative Hgb drop and postoperative complications.

Material-Method Patients were divided into 2 groups: Those with MAP score < 3 and ≥ 3. The impact of the MAP score on the demographic, clinical, and surgical parameters of the groups was assessed and analyzed. The relationship between MAP score and complications based on Clavien Dindo classification was also examined. The study investigated factors affecting the development of complications, the amount of bleeding, and the influence of MAP scores on these outcomes.

Results The Hgb drop was 2.56 ± 1.00 in the group with a MAP score ≥ 3 which was statistically significantly higher than the group with a MAP score < 3 (1.43 ± 1.21) ($p < 0.001$). The stone-free rate was 81.7% in the group with a MAP score < 3, which was statistically significantly higher than the group with a MAP score ≥ 3 (59.6%) ($p = 0.012$).

Conclusion As the MAP score of patients scheduled for standard PNL operation increased, there was a corresponding rise in Hgb drop, a decline in stone-free rates and an uptick in postoperative urinary complications of postoperative urinary infections.

Keywords Kidney calculi, Percutaneous nephrolithotomy, Postoperative complications, Bleeding

*Correspondence:
Veli Mert Yazar
vmyazar@gmail.com
[1]Department of Urology, Afyonkarahisar Health Sciences University, Afyonkarahisar 03100, Turkiye, Turkey
[2]Department of Urology, Afyonkarahisar State Hospital, Afyonkarahisar, Turkey

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Introduction

Upper urinary tract stones are a common condition in urology clinics. Percutaneous nephrolithotomy (PNL) is an effective procedure commonly used in the treatment of this condition [1, 2]. PNL is the process of entering the kidney through a percutaneous tract and removing large kidney stones after fragmenting with intracorporeal lithotripsy and evacuating by the forceps. As reported in the literature, PNL is a commonly used procedure for complicated kidney stones larger than 2 cm, renowned for its high stone-free rate [3]. However, in comparison to other procedures for urolithiasis, PNL is characterized by notably high rates of both intraoperative and postoperative bleeding [4]. In studies, blood transfusion rates due to bleeding in PNL have been reported to reach as high as 20%, with an average rate of 7% [5].

The Mayo adhesive probability (MAP) scoring system is a well-validated assessment tool. This scoring is used to predict oncological outcomes and intraoperative complications after partial nephrectomy by using the thickness and adhesion of perinephric adipose tissue. The distance between the renal capsule and the body wall is measured at the level of the renal vein (<1 cm=0 points, 1.1=1.9 cm=1 point, > 2.0 cm=2 points). The stranding score is measured (no stranding=0 points, mild stranding=2 points, severe stranding=3 points). The scores are added together to give a MAP score (score 0=5) [6, 7].

In 2012, Mandal et al. modified the Clavien-Dindo scale for stone operations such as ureteroscopy, retrograde intrarenal surgery and PNL [8, 9].

The relationship between MAP scoring and the modified Clavien-Dindo complication scale in PNL operations was investigated in this study. We also examined the relationship between MAP scoring and clinical and demographic findings of the patient, especially postoperative Hgb drop and postoperative complications.

Materials and methods

The study was conducted at the Urology Clinic of Afyonkarahisar University of Health Sciences Hospital. Following ethical approval from the Clinical Research Ethics Committee of Afyonkarahisar University of Health Sciences (2011-KAEK-2, 2024/18), the data were collected retrospectively. The study was carried out in accordance with the principles of the Helsinki Declaration.

Patients who underwent PNL operation for complex or large (≥2 cm) kidney stones between November 2020 and November 2023 in the Urology Clinic of Afyonkarahisar University of Health Sciences in Turkiye were included in the study. Patients requiring more than one access to reach the stone, individuals with anatomical kidney anomalies such as horseshoe kidneys, and pediatric patients under the age of 18 were excluded from the study. Patients with bleeding disorders or those under anticoagulant therapy were not considered for inclusion in the study. Consequently, the study proceeded with a total of 112 patients.

The maximum stone area was measured as mm^2 based on the axial CT image, and in the case of multiple stones, the stone area was calculated by adding the area of each stone. Localization of the stone was classified as renal pelvis, calyx or renal pelvis+calyx regardless of its size. "Stone-free" was defined as the absence of stones or the presence of clinically insignificant stones measuring<4 mm on X-ray of KUB, ultrasonography, or non-contrast CT performed two weeks after surgery. A body temperature>38 °C was defined as fever. The Hgb drop was defined as the difference between Hgb values obtained 24 h before the operation and those taken 24 h after the operation. The mean value of HGB decreases in all patients was calculated as 1.75 g/dl. Since the distribution of patients with HGB decreases below and above this value was found to be appropriate, two groups were created as below and above this value. All patients were operated on after a preoperative sterile urine culture. Preoperative computed tomography (CT) image, hemogram and creatinine values were available for all the participants.

All operations were performed in the prone position under general anesthesia and using the same surgical technique. The procedure was performed by one of the three surgeons with PCNL experience of over 200 cases. All patients' tract sizes were dilated up to 30 FR. The MAP score was calculated and reported by the same radiologist who was unaware of the success and data of the operation. MAP scores were calculated based on preoperative CT images. The complication grading in this study was based on the Modified Clavien Grading System as defined by Tefekli et al. [10] (Table 1).

Patients were divided into 2 groups: Those with MAP score<3 and ≥3. The impact of the MAP score on the demographic, clinical, and surgical parameters of the groups was assessed and analyzed. The relationship between MAP score and Clavien grade was also examined. The study investigated factors affecting the development of complications, the amount of bleeding, and the influence of MAP scores on these outcomes. Major life-threatening complications were defined as conditions requiring treatment in postoperative intensive care units.

Statistical analysis

Statistical analysis of the study data was performed with the IBM SPSS (Statistical Package for the Social Sciences) version 20.0 program. The Kolmogorov-Smirnov (K-S) test was used to check whether the variables had a normal distribution. For comparing paired groups, the Student's T-test was used for normally distributed variables, while the Mann-Whitney U test was used for

Table 1 Modified Clavien Grading System

Grade 1
Fever
Transient elevation of serum creatinine
Grade 2
Blood transfusion
Urine leakage < 12 h
Infections requiring additional antibiotics (instead of prophylactics)
Wound infection
Urinary tract infection
Pneumonia
Grade 3a
Double-J stent placement for urine leakage > 24–48 h
Double-J stent placement for UPJ and pelvic injury
Urinoma
Pneumothorax
Retention and colic due to blood clots
Grade 3b
Ureter-bladder stone
Calyx neck stricture
UPJ obstruction
AV fistula
Perirenal hematoma that needs intervention
Perinephric abscess
Perioperative bleeding necessitating the cessation of surgery
Grade 4a
Neighboring organ injury
Myocardial infarction
Nephrectomy
Lung failure
Grade 4b
Urosepsis
Grade 5
Death

parameters that did not have a normal distribution. Multivariate cross-tabulations were assessed using either the Chi-square test or the Fisher Exact test. The relationship between the Clavien grade and the MAP score was analyzed with the Pearson correlation test. Logistic regression analysis was used to determine the factors affecting the development of complications and Hgb drop. Results were considered statistically significant when $p<0.05$.

Table 2 Clinical characteristics of PCNL patients according to MAP score < 3 and ≧ 3

	MAP score < 3 *N* = 60 *n* %	**MAP score ≥ 3 *N* = 52 *n* %**	***p***
Age	46.22 ± 14.35	51.79 ± 12.60	0.032
Gender	18 (30)	13 (25)	0.673
Female	42 (70)	39 (75)	
Male			
Comorbidity	29 (48.3)	21 (40.4)	0.449
Yes	31 (51.7)	31 (59.6)	
No			
Operation History	34 (56.7)	29 (55.8)	0.978
No	14 (23.3)	11 (21.2)	
RIRS	7 (11.7)	8 (15.4)	
PCNL	3 (5)	2 (3.8)	
Open	2 (3.3)	2 (3.8)	
Multiple			
ASA Score	52 (86.7)	44 (84.6)	0.792
1–2	8 (13.3)	8 (15.4)	
3–4			
Side	25 (41.7)	28 (53.8)	0.255
Right	35 (58.3)	24 (46.2)	
Left			
Stone Size(mm^2)	674.96 ± 451.06	829.53 ± 517.52	0.094
Stone Location	15 (25)	5 (9.6)	0.098
Pelvis	8 (13.3)	7 (13.5)	
Calyx	37 (61.7)	40 (76.9)	
Pelvis + Calyx			
HU	1142.95 ± 314.73	1072.94 ± 328.12	0.252
Creatinine (mg/dl)	0.85 ± 0.22	0.85 ± 0.21	0.857
Hgb Drop (mg/dl)	1.43 ± 1.21	2.56 ± 1.00	**< 0.001**
Duration of Operation	69.92 ± 41.46	80.42 ± 41.93	0.186
Stone Free Rate (%)	81.7	59.6	**0.012**
Post-op ES Replacement	5 (8.3)	4 (7.7)	0.901
	55 (91.7)	48 (92.3)	
Performed			
Not performed			
Duration of Hospitalization (days)	4.48 ± 1.33	4.88 ± 1.58	0.205
Complications	9 (15)	21 (40.4)	**0.003**
Yes	51 (85)	31 (59.6)	
No			

(MAP score: Mayo Adhesion Probability score, RIRS: Retrograde Intrarenal Surgery, PCNL: Percutaneous nephrolithotomy, ASA score: American Society of Anesthesiologists score, HU: Hounsfield Unit, ES: Erythrocyte Suspension)

Results

The mean age of the 112 participants was 48.80 ± 13.79 years and it was statistically significantly higher in the group with a MAP score ≥ 3 ($p=0.032$). Eighty-one (72.3%) of the patients were male and no significant difference was found between the groups ($p=0.673$). There were no statistically significant differences observed between the groups in regards to comorbidity, prior surgical history, ASA (American Society of Anesthesiologists) score, and the side of operation ($p=0.449$, $p=0.978$, $p=0.792$, $p=0.255$, respectively). Stone size, stone location, HU (Hounsfield Unit) and preoperative creatinine value were similar between the groups ($p=0.094$, $p=0.098$, $p=0.252$, $p=0.857$, respectively). While the Hgb drop was 1.43 ± 1.21 in the group with a MAP score < 3, the Hgb drop was 2.56 ± 1.00 in the group with a MAP score ≥ 3 which was statistically significantly higher than the group with a MAP score < 3 ($p<0.001$). The duration of operation and hospitalization were similar for the two groups ($p=0.186$, and $p=0.205$, respectively). The stone-free rate was 59.6% in the group with a MAP score ≥ 3 and 81.7% in the group with a MAP score < 3, which was statistically significantly higher than the group with a MAP score ≥ 3 ($p=0.012$). When evaluating the development of complications regardless of grading, complications were observed to occur in 9 (15%) patients in the group with a MAP score < 3 and 21 (40.4%) patients in the group with a MAP score ≥ 3, which was statistically significantly higher compared to the other group ($p=0.003$) (Table 2).

When all patients in the study were evaluated, the most common Modified Clavien grade was grade 2 with 13 (11.6%) patients (excluding patients without complications). The most common MAP score was MAP score 3 with 33 (29.5%) patients.

In the cross-tabulation of MAP score and the Modified Clavien complication grading system, MAP scores of patients who developed complications were high and statistically significant (Pearson Chi-Square $p=0.001$) (Table 3). Furthermore, correlation analysis revealed a moderate positive relationship between the MAP score and Clavien's grade, which was statistically significant ($r=0.356$, $p<0.001$).

Binary logistic regression analysis was performed to identify the possible independent predictors of the development of complications and Hgb drop that contributed most to the outcome. The model predicting the development of complications and Hgb drop was significant (χ2 [8] = 17.91, $p=0.022$, χ2 [8] = 7.88, $p=0.444$, respectively) and could explain 36.8% and 66.4% of the variance in reincarceration (Nagelkerke R2 = 0.368, Nagelkerke R2 = 0.664, respectively). The model correctly predicted 76.8% of patients with complication development and 86.6% with Hgb drop. The most important predictor for the development of complications, Grade 2 complications

Table 3 Comparison of the MAP score with the modified clavien complication classification

		MAP Score						
		0 n %	1 n %	2 n %	3 n %	4 n %	5 n %	Total n %
Modified Clavien Grading	**0**	12 (14.6)	21 (25.6)	18 (22)	20 (24.4)	10 (12.2)	1 (1.2)	82 (100)
	1	0 (0)	0 (0)	5 (62.5)	3 (37.5)	0 (0)	0 (0)	8 (100)
	2	0 (0)	0 (0)	1 (7.7)	7 (53.8)	5 (38.5)	0 (0)	13 (100)
	3a	0 (0)	1 (20)	2 (40)	1 (20)	1 (20)	0 (0)	5 (100)
	3b	0 (0)	0 (0)	0 (0)	2 (66.7)	0 (0)	1 (33.3)	3 (100)
	4b	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)
	Total	12	22	26	33	17	2	112

(Pearson Chi-Square $p=0.001$, MAP Score: Mayo Adhesive Probability score)

Table 4 Logistic regression analysis of predictors affecting Complication Development and Hgb Drop

Risk Factor	Total Complication		Modified Clavien Grade 2 Complications		Hgb Drop ≥ 1.75 g/dl	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Age (years)	0.979 (0.933–1.026)	0.378	0.958 (0.895–1.025)	0.210	1.037 (0.981–1.096)	0.196
Gender	1.709 (0.562–5.190)	0.345	0.903 (0.141–5.776)	0.914	0.780 (0.194–3.127)	0.725
Side	1.300 (0.443–3.817)	0.633	0.944 (0.205–4.337)	0.940	0.277 (0.077–0.995)	0.049
Comorbidity	1.531 (0.390–6.016)	0.541	1.412 (0.189–10.528)	0.737	1.119 (0.231–5.405)	0.889
ASA Score	2.238 (0.738–6.782)	0.155	0.877 (0.224–3.441)	0.851	0.373 (0.113–1.239)	0.107
Duration of Operation	1.001 (0.988–1.013)	0.930	1.011 (0.992–1.030)	0.270	1.010 (0.992–1.028)	0.269
Stone Size	1.001 (0.999–1.002)	0.319	1.001 (0.999–1.003)	0.188	1.000 (0.998–1.001)	0.563
HU	0.999 (0.998–1.001)	0.297	1.001 (0.999–1.004)	0.333	1.000 (0.998–1.001)	0.670
Stone Localization	0.922 (0.445–1.911)	0.827	0.646 (0.208–2.003)	0.450	1.323 (0.553–3.166)	0.530
RIRS History	1.463 (0.478–4.480)	0.505	2.242 (0.424–11.867)	0.342	0.523 (0.137–1.997)	0.343
PCNL History	0.084 (0.008–0.829)	**0.034**	0.000 (0.000–0.000)	0.998	1.955 (0.323–11.841)	0.465
Open Surgery History	1.381 (0.130-14.624)	0.789	2.212 (0.115–42.725)	0.599	3.492 (0.096–127.12)	0.495
MAP Score	2.407 (1.352–4.285)	**0.003**	4.475 (1.577–12.700)	**0.005**	6.784 (3.250–14.160)	**< 0.001**

(RR: relative risk reported with odds ratio, CI: confidence interval, MAP score: Mayo Adhesive Probability score, RIRS: Retrograde Intrarenal Surgery, PCNL: Percutaneous nephrolithotomy, ASA score: American Society of Anesthesiologists score, HU: Hounsfield Unit)

according to the Clavien scale, and HGB drop was high MAP score ($p=0.003$, $p=0.005$, $p<0.001$, respectively). One unit increase in the MAP score increased the risk of complication by 2.4 times (Table 4).

Discussion

PNL has a faster postoperative recovery and shorter hospitalization durations than traditional open surgery. However, complications can still occur following PNL. One of the most significant complications is bleeding [11]. In our study, drop in Hgb were observed to be more pronounced in patients with a MAP score of 3 and above and this decrease was statistically significant. The primary reason for this is believed to be the thickness of the perinephric adipose tissue, which is a determining factor in the MAP score. Thicker perinephric adipose tissue is associated with increased bleeding during the procedure. In our study, the MAP score was the most important predictor for Hgb drop. Logistic regression analysis of predictive factors affecting Hgb decrease and complication development revealed that the most important factor was the MAP score. There is no study in the literature that has performed logistic regression analysis on MAP scores. We believe that the data we obtained will provide a new perspective to the literature.

Chen et al. found that patients with postoperative fever and urinary tract infection had higher MAP scores [12]. In our study, higher MAP scores were observed in patients who developed postoperative infection. This was found to be statistically significant. We believe that the cause of UTI is related to increased lymphatic pressure, inflammation and edema of the retroperitoneal tissues surrounding the stone.

In a study by Wishahi et al. in 2023, the mean hospitalization duration in standard PNL patients was reported as 3.4±1.1 days [13]. In our study, the mean duration of hospitalization was 4.48±1.33 days in patients with a MAP score below 3 and 4.88±1.58 in patients with a MAP score of 3 and above. No significant relationship was found between the length of hospital stay and Map score.

The mean duration of standard PNL was found to be 72±14.9 min in the article published by Qin et al. [14]. In our study, it was found to be 69.92±41.46 min in patients with a MAP score below 3 and 80.42±41.93 min in patients with a MAP score of 3 and above. This difference was not statistically significant.

While the overall stone-free rate was found to be 85–89% in standard PNL operations [15], this rate was 81.7% in our patients with a MAP score below 3 and 59.6% in our patients with a MAP score of 3 and above. This difference was not statistically significant. The main reason for this phenomenon is believed to be that as patients' MAP scores increase, intraoperative bleeding also increases. This can lead to difficulties in visualizing the stones clearly, hindering the ability to perform detailed stone crushing and collection during the procedure.

In our study, based on the modified Clavien-Dindo scale, complications were categorized as follows: grade 0 in 82 patients, grade 1 in 8 patients, grade 2 in 13 patients, grade 3a in 5 patients, grade 3b in 3 patients, and grade 4b in 1 patient. It was observed that there was an increased likelihood of complications as the MAP scores of the patients increased. This was found to be statistically significant. The MAP score was identified as the most significant factor in predicting grade 2 complications. The most common second-stage complication observed was urinary tract infections requiring antibiotic treatment.

There are some limitations of our study. One of them is the relatively small number of patients and its single-center design. Another contributing factor to this is the exclusion of the pediatric age group and patients with renal anomalies to maintain a homogeneous patient population. The logistic regression analysis between the parameters statistically strengthened the study. Other factors such as complexity of the stone, amount of hydronephrosis, tract size, history of ESWL, which may affect complications such as bleeding, are not used in the classification and scoring. It should be taken into account that such factors may also affect complication rates.

Conclusion

As the MAP score of patients scheduled for standard PNL operation increased, there was a corresponding rise in Hgb drop, a decline in stone-free rates, and an uptick in postoperative urinary tract infections. Postoperative infection was higher even when PCNL was performed with a negative pre-op urine culture. We think that MAP score can help the surgeon to preoperatively predict the likelihood of complications. We also believe that this study would serve as a basis for future research in this field.

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Author contributions
VMY: Conception and design, collected data, analysis and interpretation of data, final approvalOG: Collected data, reviewed the paper, drafting of the manuscript and final approval.KT: Collected data, analysis and interpretation of data, final approvalKU: Conception and design, collected data, analysis and interpretation of dataRU: Conception and design, analysis and interpretation of data, final approvalAll authors had full access to the data, contributed to the study. All authors read and approvedthe final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from thecorresponding author on reasonable request.

Declarations

Ethical approval and consent to participate
This study was approved by the Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (2011-KAEK-2, 2024/18). All methods were carried out in accordance with the relevant guidelines and regulations of the Helsinki Declaration. Written informed consent was obtained from the parents or legal guardians of the participants included in the study. Clinical trial number: not applicable.

Consent for publication
As this study involved a retrospective review, consent was not required.

Competing interests
The authors have no competing interests to declare that are relevant to the content of this article.

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