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ORIGINAL ARTICLE

Factors affecting hospital readmission and rehospitalization following percutaneous nephrolithotomy

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Abstract
Purpose To identify patient- and procedure-related factors that increase the risk of hospital readmission and emergency room (ER) visits after percutaneous nephrolithotomy (PNL).
Materials and methods We retrospectively reviewed the records of patients with kidney stones treated via PNL in two tertiary referral hospitals between 2008 and 2014. Patient demographics including age, body mass indices, ASA score, stone size, presence of anatomic abnormality and comorbidity, operative and postoperative measures, and ER visit and rehospitalization rates were reviewed. Unplanned readmission to the hospital, including elective, and ER visits due to any reason related to the PNL procedure were primarily examined. The factors affecting ER visit and rehospitalization rate were analyzed using logistic regression analysis.
Results A total of 1024 patients (mean age 46.57 years) were enrolled into the study. Mean stone size was 28.5 mm. Stone-free status was achieved in 81.7 % of the procedures. Complications occurred at a rate of 6.44 % in the postoperative period. ER visit and rehospitalization rates were 5.76 and 5.27 %, respectively. While stone complexity, anatomic abnormalities, and postoperative course were found to be factors affecting ER visit, postoperative course and hospitalization time were main predictors for rehospitalization rate.
Conclusions Our outcomes demonstrate that patients, who had an anatomic abnormality and complex kidney stone, were more likely to have an unplanned hospital readmission. Patients with a history of perioperative and/or postoperative complication seem to have a tendency to unplanned readmission and rehospitalization.

Keywords Percutaneous nephrolithotomy · Hospital readmission · Rehospitalization · Risk factor

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Introduction

The worldwide prevalence of kidney stones has gradually increased over the years [1, 2] to attain a current incidence of 8.8 %; thus, 1 in 11 people in the USA has suffered from kidney stones [2]. The equipment used for stone removal has been optimized to minimize morbidity. In the time since its introduction in 1976, percutaneous nephrolithotomy (PNL) has been extensively refined to minimize postoperative complications, pain, the duration of hospitalization, and the hospital readmission (HR) rate [3]. Besides conventional PNL, miniperc, tubeless PNL, microperc, ultraminiperc are improved for the treatment of kidney stones subsequently considering these facts mentioned above [4–6].

HR or emergency room (ER) visits after surgery are considered to be negative indicators of healthcare quality and are associated with significant economic burdens. In

2010, the USA spent $17.5 billion on HR rates [7], rendering it essential to minimize such events. However, to date, few studies have addressed either the frequency of HR and/or unplanned care or factors potentially predictive of such needs, after urological surgical procedures [8–11].

In the present study, we identified patient- and procedure-related factors that increase the risk of HR and ER visits after PNL. To the best of our knowledge, this is the largest two-center series describing predictors of HR after PNL.

Materials and methods

We retrospectively reviewed the records of patients with kidney stones treated via PNL in two tertiary referral hospitals between 2008 and 2014. Unplanned readmission to the hospital, including elective, and ER visits due to any reason related to the PNL procedure were primarily examined. Hospital readmission was defined as the events within 30 days after surgery. We also included the ER visits only within 30 days in postoperative period. In addition, rehospitalization for the further treatment was noted, but we excluded the patients who underwent a second-look urologic surgical procedures including PNL and/or ureterorenoscopy.

Surgical teams experienced in endourological methods performed all of the PNL procedures. The PNL procedures were routinely completed as a single-step procedure through the percutaneous renal tract obtained by the urologist. After attaining a proper renal access with fluoroscopy guidance on patients in prone position, the tract was dilated using Amplatz dilators. A standard PNL procedure was done as described previously in the literature [12]. The operative time commenced at the time of renal puncture and ended upon the removal of the percutaneous system from the kidney. If no complication was evident, patients were routinely discharged after the removal of their urethral and ureteral catheters, and the nephrostomy tube (if placed). Success was defined as the absence of any residual fragment on ultrasonography, plain imaging, and/or computed tomography (CT; if required), 1 month after surgery. Patient demographics [age; gender; body mass index (BMI); American Society of Anesthesiologists (ASA) score; stone size and complexity [simple (isolated pelvis or calix stones) or complex stones (partial or complete staghorn, multiple caliceal stones)] [13] anatomic abnormalities; comorbidities; and procedure-related variables including the number of PNL attempts, operative time, duration of hospitalization, operative success or failure, and complications] were prospectively recorded in a hospital database. Complications were classified using the Clavien system adapted to PNL procedure [14].

Statistical analysis

Data collections were performed using the IBM SPSS version 20.0. Numerical variables are shown as means with standard deviations and categorical variables as numbers with percentages. Patient demographics and operative characteristics were compared with Chi-square and Mann–Whitney *u* tests. Multiple binary logistic regressions with backward step-wise method were used to identify independent predictors of HRs and ER within 30 days. A p value <0.05 was considered statistically significant.

Results

We included a total of 1024 patients [650 (63.4 %) males and 374 (36.6 %) females]. Mean patient age was 46.57 ± 13.19 years, and mean patient BMI was 26.6 ± 5.05 kg/m^2 (13.8–38.4 kg/m^2). Among these 1024 patients, 59 (5.76 %) were readmitted within 30 days of surgery and rehospitalization rate was 5.27 %. Of all readmitted patients, 33 % had at least one comorbidity. The ASA scores were I in 508 (49.6 %), II in 439 (42.87 %), and III in 77 (7.51 %). The mean stone diameter was 28.5 ± 12.9 mm. The demographic features and stone characteristics of all patients are summarized in Table 1.

Given the operative outcomes, PNL procedures were completed with a mean access number of 1.12 ± 0.35 (1–3) after an average duration of 59.91 ± 29.06 min (20–210 min). Stone-free status was achieved in 837 patients (81.73 %) on postoperative day one, and of the residual

Table 1 Demographic measures of the patients enrolled into the study

N	1024
Mean age (years)	46.57 ± 13.19
Sex (male/female)	650/374
Mean BMI (kg/m^2)	26.6 ± 5.05 (13.8–38.4)
Mean ASA score	1.57 ± 0.62 (1–3)
ASA score (*n*)	
1	508 (49.6 %)
2	439 (42.87 %)
3	77 (7.51 %)
Mean stone size (mm)	28.5 ± 12.9 (7–64)
Stone configuration	
Simple	599 (58.49 %)
Partial staghorn	101 (9.86 %)
Complete staghorn	59 (5.76 %)
Multiple calyceal	265 (25.87 %)
Anatomic abnormality rate	27/1024 (2.63 %)
Comorbidity rate	338/1024 (33.00 %)

Table 2 Perioperative variables and outcomes

Mean access number	1.12 ± 0.35 (1–3)
Mean operation time (min)	59.91 ± 29.06 (20–210)
Mean hospitalization time (days)	3.28 ± 1.99 (0–14)
Success rate	
Stone free	837/1024 (81.73 %)
Fragments <4 mm	53/1024 (5.17 %)
Rest	134/1024 (13.08 %)
Complication rate (%)	66/1024 (6.44 %)
Unplanned readmission rate (%)	59/1024 (5.76 %)
Rehospitalization (%)	54/1024 (5.27 %)

Table 3 Categorization of the perioperative complications

Clavien grade 1	19 (1.8 %)
Fever	15 (1.5 %)
Urine leakage	3 (0.3 %)
Deranged renal function	1 (0.1 %)
Clavien grade 2	33 (3.2 %)
Bleeding	17 (1.6 %)
Urinary tract infection	15 (1.5 %)
Atelectasis	1 (0.1 %)
Clavien grade 3A	12 (1.2 %)
Hydro/hemothorax	4 (0.4 %)
Renal pelvis injury requiring stenting	1 (0.1 %)
Urine leakage managed by ureteral stenting	7 (0.7 %)
Clavien grade 3B	1 (0.1 %)
Bleeding requiring angioembolization	1 (0.1 %)
Clavien grade 4	1 (0.1 %)
Urosepsis requiring ICU	1 (0.1 %)
Clavien grade 5	0
Total	66 (6.4 %)

calculi, the single fragments in size of <4 mm were seen in 53 of remaining patients (5.17 %) (Table 2). However, complications were observed in 6.44 % of patients (Table 3). Of all readmitted patients, the most common diagnoses were renal colic (50.8 %), urinary tract infection (28.8 %), prolonged urine leakage (6.7 %), and hemorrhage requiring blood transfusion (6.7 %). Two patients also underwent angioembolization for recurrent hemorrhage. Additionally, three patients had pulmonary conditions including pneumonia and atelectasis, and one patient was followed up for acute renal failure but did not require hemodialysis.

On the other hand, univariate analysis revealed that the unplanned readmission rate was statistically associated with the presence of anatomic abnormality, stone complexity, and procedure time. On the other hand, rehospitalization rate was statistically related with higher ASA score, hospitalization time (Table 4). The presence of postoperative complication was associated with both readmission and rehospitalization. On multivariate analysis, the presences of anatomic abnormality and postoperative complication, and stone complexity carried the risk of unplanned readmission. Meanwhile, hospitalization period and the presence of postoperative complication were also found to be the most significant independent predictors for rehospitalization (Table 5).

Table 4 Univariate analysis of the factors affecting the ER visit and rehospitalization rate

	p^a	p^b
Age	0.81	0.92
Sex	0.66	0.73
BMI	0.83	0.17
Comorbidity	0.063	0.33
ASA score (1, 2, 3)	0.42	0.04
Anatomic abnormality (yes/no)	0.004	0.61
Stone size (cm)	0.48	0.6
Stone complexity	<0.0001	0.09
Access number	0.91	0.08
Access location (supra/infra costal)	0.66	0.85
Surgery time	0.01	0.12
Hospitalization time	0.98	0.001
Success of PNL procedure	0.036	0.97
Presence of postoperative complication	<0.0001	<0.0001

[a] *p* p for unplanned readmission, [b] *p* p for rehospitalization

Discussion

For most urologists who perform surgery for urolithiasis, unplanned HR and postsurgical ER visits are of increasing concern as the prevalence of kidney stones increases [1, 2]. In addition to surgery, unplanned HR can also negatively affect a patient's quality of life and impose economic burdens.

To date, few studies have reflected this area regarding the frequency and/or potential predictive factors after urological procedures. Rambachan et al. [8] reported readmission after outpatient urological surgery occurred at a rate of 3.7 % using a national database system. The authors highlighted that history of cancer, bleeding disorder, male gender, ASA 3 and 4 were associated with readmissions. On the other hand, they obtained the data only for five most common urological procedures including cystourethroscopy and resection of bladder tumor, laser prostatectomy, transurethral resection of prostate, hydrocele excision, and sling surgery for urinary incontinence, and the main drawback in their database system was lack of capturing of stone disease that was possibly associated with higher

Table 5 Multivariate analysis for unplanned readmissions and rehospitalization

	p	Odds ratio	*B*	95 % CI
Dependent: unplanned readmissions				
Anatomic abnormality	<0.001	2.630	0.967	1.530–4.522
Complication	<0.001	3.488	1.249	2.510–4.847
Stone complexity	<0.001	2.13	0.75	1.25–3.64
Dependent: rehospitalization				
Complication	<0.001	2.264	0.817	1.573–3.260
Hospitalization time	<0.001	1.249	0.222	1.122–1.390

CI confidence interval

rates of HR. In a recently published study HR rate following shockwave lithotripsy (SWL), ureteroscopy (URS) and PNL were investigated using data from the marketscan including more than 170 million beneficiaries covered by private insurance in USA [15]. According to the outcomes of their study, SWL has the lowest unplanned visit rate (12 %) compared to URS (15 %) and PNL (15 %).

However, our present study differs from other studies in terms of consisting only PNL procedures. Meanwhile, in another study, Armitage et al. [9] gave originality to this area and analyzed a PNL database from the UK containing details of 5750 index PNL procedures performed in 165 hospitals. The authors noted a readmission rate of 9.0 % and a rate of 0.2 % regarding in-hospital deaths within 30 days of surgery regarding their primary outcomes. In addition, they examined the association between the risk of complication and patients' characteristics including the age at admission, sex, and comorbidities using an updated version of the Charlson comorbidity score. Recently, Beiko et al. [11] reported their ambulatory PNL series including the assessment of rates of emergency department (ED) visits and readmissions postambulatory PNL. The authors noted a rate of 12 % for returning to ED and 4 % for readmission rate. In the study reported by Scales et al. facility volume and comorbidity scores were found to be related to unplanned visit following SWL, URS, and PNL procedures. As distinct from the other studies, we also included the operative and perioperative parameters such as success rates, stone complexity, hospitalization, and operation times.

We report our clinical study with regard to identify the patient and procedure-related factors that may increase the risk of HRs and rehospitalization after PNL. According to the best of our knowledge, this present study is the first largest two-center series in this area for PNL as a distinct from other reports. Similar to other reports, our series also comprised individuals who readmitted within 30 days of surgery. In present study, besides the postoperative outcomes including the parameters such as success rate, we were also able to include the factors such as anatomic abnormality, stone complexity, operative time, and hospitalization time owing to obtain the data from only two centers. The unplanned HR was similar to those of other reports. However, no mortality occurred after PNL, unlike what was noted in previous reports. Anatomic abnormalities and complex kidney stones were predictors of HR. In addition, as found in previous studies, patients with histories of peri- and/or postoperative complications tended to be readmitted.

Herein, we may also argue that how urologists may benefit from such results. We consider that the identification of HR risk factors may improve the compliance between patient and physician, to guard against HR. In addition, urologists may select patients requiring detailed consultations prior to discharge. On the other hand, prevention of complications and proper management of complications may reduce the HR and rehospitalization.

We have also some limitations for present study that should be addressed. Although data were entered prospectively into a database, our work was retrospective in nature. Data about the stone composition and previous urine culture were not collected and analyzed in the study. In addition, the economic costs of HR and ER visits were not calculated, although such costs impose major constraints on healthcare systems. We had no data of the mean readmission time. However, despite these drawbacks, we sought to reflect the area about the unplanned readmissions after PNL.

Conclusions

Our outcomes demonstrate that patients, who had an anatomic abnormality and complex kidney stone, were more likely to have an unplanned HR. Moreover, we found that patients with a history of perioperative and/or postoperative complication also seem to have a tendency to unplanned HR and rehospitalization.

Authors' contributions A.T., T.K. and A.U contributed to the study design, writing and interpretation. A.Tok, E.O., S.K., and OT.K. collected the data. I.B. conducted the statistical analysis and created the figures.

Compliance with ethical standard

Conflict of interest The authors declare that they have no competing interest.

Ethical standard The study was performed in accordance with the Declaration of Helsinki and its amendments. All patients provided written informed consent.

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