Original Article

SAGE Open Medicine

SAGE Open Medicine
Volume 13: 1–9

DOI: 10.1177/20503121251318902
journals.sagepub.com/home/smo

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Operation time as a prognostic indicator on postoperative complications following percutaneous nephrolithotomy

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Abstract

Objective: We aimed to find an optimal cut-off time for percutaneous nephrolithotomy to prevent complications.

Methods: This study enrolled 165 patients aged 18–80 with renal stones ⩾2 cm or ⩾1 cm in lower pole, confirmed via noncontrast computed tomography. Baseline characteristics, stone features, operation time, and anesthesia time were recorded. Logistic regression models were fitted and the ability of the surgery time to predict complications, major complications, and systemic inflammatory response syndrome was evaluated using receiver-operating characteristic curves. Area under the receiver-operating characteristic curve analysis was used as a general indicator of quality.

Results: Out of 165 enrolled patients, 157 were analyzed (8 excluded due to follow-up and surgery data issues). The cohort consisted of 115 males (73.2%) and 42 females (26.7%), with a mean (SD) age of 47.4 (12.65) years. Multivariate analysis indicated that longer operation times and lower body mass index correlated with higher complication rates. A cut-off of 65 min for operation time showed 96.8% specificity for predicting complications. Additionally, 47.8% of patients were systemic inflammatory response syndrome positive postprocedure, and operation times were not shown to be predictive of systemic inflammatory response syndrome.

Conclusion: Operation time seemed to be a potential risk factor for postpercutaneous nephrolithotomy complications and lowering the operation time could prevent postoperative complications.

Keywords

Percutaneous nephrolithotomy, operation time, complications, systemic inflammatory response syndrome

Date received: 4 December 2024; accepted: 21 January 2025

Introduction

Percutaneous nephrolithotomy (PCNL) is a minimally invasive endourological procedure used to treat renal calculi, achieving a stone-free rate of up to 95%.[1,2] PCNL has become one of the most common urologic surgeries since the first successful percutaneous removal of renal calculus in 1976.[3] The primary objective of PCNL is complete clearance of the stone.[4] According to the European Association of Urology guidelines, PCNL is the first-line approach for large (>2 cm), multiple, and staghorn renal stones.[5] Additionally, it is recommended that stones larger than 1 cm located in lower pole calyces be removed via PCNL.[6] Furthermore, PCNL is considered the gold standard method for managing stones in the calyceal diverticulum.[2] PCNL is a controlled Grade IV renal injury, and hemorrhage may occur at various stages of the surgery, including puncture, tract dilatation, and stone disintegration.

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Complications are an inherent component of PCNL procedures, impacting surgical outcomes, patient well-being, healthcare expenditures, and quality of life. While bleeding is a common occurrence during PCNL, the necessity for blood transfusion is infrequent, with an overall incidence rate of 7%. Post-PCNL complications such as fever and urinary tract infections are prevalent, constituting approximately 21%–39.8% of all adverse events, whereas urosepsis, although rare, poses a significant risk. Additional potential complications associated with PCNL encompass organ injuries (e.g., liver, spleen, gastrointestinal tract), intravascular fluid overload, nephrocutaneous fistula-induced urine leakage, postoperative pain, and thromboembolism, persisting despite advancements in procedural techniques and equipment.[4,5,7–9]

Various factors contribute to adverse events following surgeries, including patient comorbidities, surgeon proficiency, and hospital-related variables. While some factors are unalterable, certain variables such as operation time can be modified. The impact of operation time on complications has garnered considerable attention, with prolonged procedures identified as a modifiable risk factor for postoperative issues such as infections, sepsis, and cardiopulmonary complications. Previous research has highlighted the correlation between operation time and complications such as infections, thromboembolism, hemorrhage, and tissue necrosis.[10–12]

This study aims to evaluate the influence of operation time on post-PCNL surgical complications. Additionally, an effort was undertaken to establish a cut-off time beyond which the rates of complications significantly increase. It was hypothesized that the complication rate would rise following an extended duration of surgical procedures.

Materials and methods

Study design

This prospective cohort study was conducted at Sina Hospital in Tehran, Iran, from November 2023 to May 2024. Patients were included in our study after signing the written informed consent from Persian Registry for Stones of Urinary System (PERSUS). The study protocol received approval from the ethics committee of Tehran University of Medical Sciences (IR.TUMS.SINAHOSPITAL.REC.1402.011). The study adhered to the principles outlined in the Helsinki Declaration.

Patients

A total of 165 patients with renal stones who visited the urology clinic were enrolled in the trial. Inclusion criteria comprised an age range of 18–80 years, confirmation of renal stones by noncontrast-enhanced computed tomography (CT) scan, stone size ⩾2 cm or ⩾1 cm in lower pole, and willingness to participate in the research. Exclusion criteria included a history of genitourinary surgery, bilateral renal stones, anatomical or functional disorders of the genitourinary system, positive urine culture before surgery, severe hydronephrosis, use of immunosuppressive drugs before surgery, diabetes mellitus, coagulopathy disorders, uncontrolled systemic diseases, contraindication for general anesthesia, body mass index (BMI) greater than 30, and pregnancy.

The sample size was computed by GPower 3.1. based on the type 1 error of 0.05, the type 2 error of 10%, and the presence of three groups in the study. The IBM SPSS Statistics Basic (Versions 29) were used fo statistical analysis and analysis of variance (ANOVA) testing was employed to assess the mean operation time, which constituted the primary objective of the investigation, with an anticipated effect size of 0.33. Consequently, a minimum of 31 participants was calculated for each group one-way analysis of variance (ANOVA) for comparisons of three or more independent groups. Recruitment efforts were sustained until at least 31 patients were enrolled in each group.

Baseline characteristics data

Baseline characteristics such as age, gender, BMI, and medical history were collected during the initial visit. Totally tubeless PCNL was performed for all patients by an expert urologist. Stone features, including size and location, were documented via noncontrast-enhanced CT scan. For each patient, 1 mg of intravenous ceftriaxone was used as a prophylaxis before the surgery.[13] Operation time was defined as the duration between needle puncture and removal of the amplatzer and was recorded for all patients. In addition to the operation time, the duration of anesthesia was also documented for each patient. American Society of Anesthesiologists (ASAs) classification score and Charlson comorbidity index (CCMI) were calculated for each participant.[14,15]

Complications data

The primary aim of this study was to assess the relationship between surgery time and complications occurring within the first month following PCNL. Complications were classified according to the Clavien–Dindo classification (CDC). The secondary aim was to examine the association between surgery time and the incidence of Systemic Inflammatory Response Syndrome (SIRS).[16,17]

Modified CDC was employed to document postoperative complications. Prior work by Shin et al. listed PCNL surgery complications based on the CDC. Our study utilized this established classification system to report complications.[18] Grades of complications were categorized as follows: Grade 1 encompassed transient fever, pleural effusion, or atelectasis without fever, and temporary elevation of creatinine. Grade 2 included catheter urine leakage, blood transfusion, and pneumonia. Grade 3 involved renal hemorrhage necessitating angioembolization, Double-J stent insertion for urine leakage, chest tube insertion due to hemo/pneumothorax, retention from blood clots, nephrostomy catheter dislodgement necessitating repositioning, collecting system perforation, infundibular stricture, and urethral stricture. Grade 4 comprised bowel injury, nephrectomy, and sepsis. Grade 5 represented mortality.

Systemic inflammatory response syndrome

The criteria for identifying SIRS were derived from the guidelines established by the American College of Chest Physicians in 2001. According to these guidelines, SIRS is characterized by the presence of two or more of the following parameters: a body temperature exceeding 38°C or falling below 36°C; a heart rate greater than 90 beats/min; a respiratory rate exceeding 20 breaths/min or an arterial carbon dioxide tension (PaCO2) lower than 32 mmHg; and a white blood cell count greater than 12,000 cells/µL or less than 4000 cells/µL.[19]

All procedures were conducted under general anesthesia. Prior to surgery, all patients received intravenous ceftriaxone (1 g/12 h) as prophylactic antibiotics. A standardized surgical approach was implemented by urologists for all cases. Upon anesthesia induction, patients were positioned in lithotomy and underwent ureteral catheterization using a 5-Fr catheter (later utilized for contrast infusion) under cystoscopic guidance. Using C-arm fluoroscopy guidance through the abdominal wall, a pyelogram and subsequent puncture were performed using an access needle guide (18 gauge) with a floppy tip. The needle entry was then dilated approximately 30-Fr with the needle removed but the guidewire preserved. Fluoroscopy was employed to confirm appropriate renal access. After insertion of the guidewire (0.038 inches) into the targeted calyx, an Amplatz of 30 Fr was gradually inserted. Nephroscopy (Karl Storz®, 26 Fr) was performed, and a pneumatic lithotripter (Swiss lithoclast, EMS) was utilized for stone fragmentation. Finally, fragmented stones were extracted using a grasper.

Statistical analysis

The discrete variables were reported as numbers (percent), and the Chi-squared test was used as the relevant inferential tool. Continuous variables were reported as either median (interquartile range (IQR)) or mean (standard deviation (SD)), and the Wilcoxon test and ANOVA were used in these cases. Considering the binary outcome of complication occurrence, logistic regression models were fitted, in univariate and multivariate manners. The covariates of p-values lower than 0.1 were put in the multivariate models. The ability of the surgery time to predict complications, major complications, and SIRS was evaluated using receiver-operating characteristic (ROC) curves, formulated using maximum likelihood estimation. Area under the ROC curve (AUC) analysis was used as a general indicator of quality. The analyses were performed using Stata ver. 14. Significance level of 0.05 was applied.

Results

Out of 165 patients meeting inclusion criteria, 3 were excluded due to loss of follow up, and 5 were excluded due to lack of surgery data in the study (Figure 1). Analysis was conducted on 157 patients. The 115 (73.2%) patients were male, and 42 (26.7%) were female. The mean (SD) age of the participants was 47.4 (12.65) years. Of those assessed, 31 (19.7 %) patients did not have complications, 92 (58.6%) had minor, and 34 (19.7%) had major complications. A total number of 165 complications were documented through the follow-up among the patients, out of which 111 were grade 1, 17 were grade 2, 10 were grade 3, and 27 were grade 4 according to the CDC (Table 1). The variable description is found in Table 2 in relation to the CDC.

While assessing SIRS among participants using the T-test, 47.7% were SIRS positive. Mean (SD) of operation time were 59.2 (21.62) and 53.3 (14.59) among SIRS positive and SIRS negative patients, respectively (p-value = 0.051).

Comparing the patients without complication versus patients with complication (minor or major), the occurrence of at least one complication was regarded a binary outcome in the logistic regression model, which led to the odds ratios (ORs) reported in Table 3. Multivariate analysis revealed that longer operation time and lower BMI (OR = 1.04 and 0.85, respectively) correlated with higher occurrence of complications. The logistic regression model was also used to compare the patients with major complications to others (patients with minor complications and without complications). The results are presented in Table 4. Operation time and age (OR = 1.03 and 1.04, respectively) were shown to correlate with major complication occurrence based on multivariate analysis.

The ROC curve of surgical time with an AUC of 0.631 is shown in Figure 2. It was identified by the analysis that operation time at a cut-off time of 65-min has 96.8% specificity and 31.0% sensitivity for predicting complication occurrence. A similar analysis was performed for predicting major complication occurrence, which suggested a cut-off time of 55-min with 76.5% sensitivity and 56.9% specificity. The AUC was also calculated to be 0.650 (Figure 3).

A total of 47.8% of patients were SIRS positive after the procedure. Table 5 represents the result of the logistic regression analysis of SIRS occurrence among patients. Multivariate analysis suggests that ASA score of more than 3 and younger age (OR = 2.59 and 0.97, respectively) significantly correlate to SIRS occurrence; however, operation time does not show any relation. As depicted in Figure 4, the operation time ROC curve for predicting SIRS with an AUC of 0.565 was produced. Analysis revealed that 82.9% specificity and 34.7% sensitivity of SIRS after PCNL was indicated using a cut-off of 65-min operation time.

Discussion

Regarding treating large renal calculi, PCNL is considered the first line. However, complications such as bleeding, sepsis, ATN are probable. Operation-related complications contribute to almost 40% of in-hospital complications and are more often preventable than other types of complications, although their consequences are more severe. The chance of

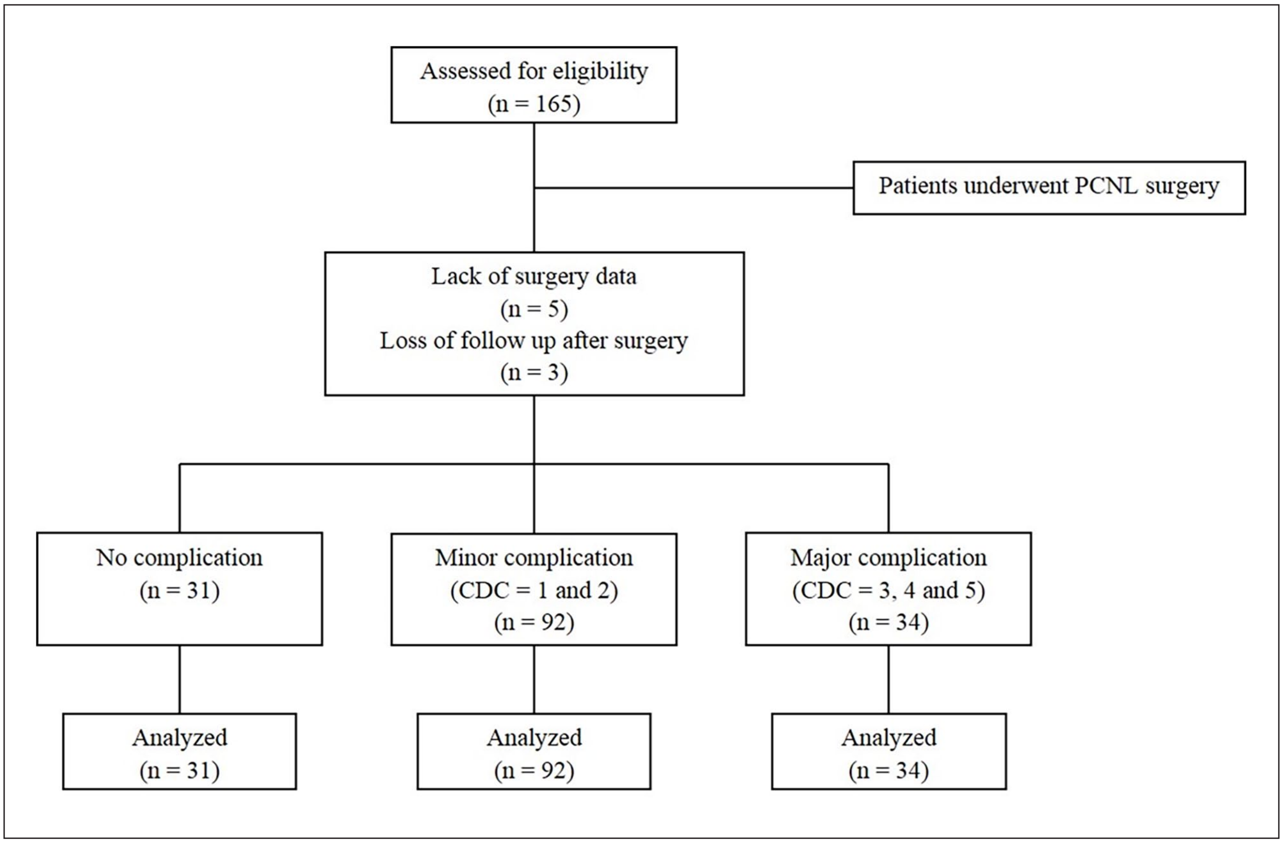

Figure 1. Flow diagram of the present trial.

Table 1. Frequency of PCNL complications during the follow up.

Complication		Frequency
Grade 1	Fever (managed without antibiotics)	80
	Postoperative pain (managed by opioid)	31
Grade 2	Bleeding (required transfusion)	10
	UTI (managed with antibiotics)	6
	Hematoma	1
Grade 3	Bleeding (required angioembolization)	8
	Pulmonary thromboembolism	2
Grade 4	Hemorrhagic shock	1
	Sepsis	4
	ICU admission	10
	Acute tubular necrosis (ATN)	12
Grade 5	Mortality	0

adverse outcomes may be reduced by improved skills and modifications in the procedure.[20–22]

In this study complications of 157 patients after PCNL surgery were documented and categorized. Our findings showed that approximately 20% of patients experienced no complication and the rest had at least on complication (from mild fever to septic shock) according to CDC, out of which 21.6% were major complications. Postoperative fever and pain (both are grade 1) were the most common complications after PCNL with rates of 51.0% and 19.7%, respectively. The modified Clavien–Dindo classification is widely used to report surgical complications after PCNL surgery. Based on the latter classification, most of PCNL complications are of low grade and incidence of major complications are very rare. De la Rosette et al.[23] conducted a study included 5803 patients, reported minor complication in 16.4% and major complications were encountered in 4.1% of cases.[23] Our findings show a higher complication rate than previous studies, which are assumed to be attributed to our hospital setting. Our hospital is a referral tertiary center, where complicated and severe patients are referred from other hospitals.

Recent studies suggested that operation time is an independent and, fortunately, modifiable complication risk factor. Our study findings revealed that operation time, age, and BMI are significantly different among patients according to the CDC (none, minor, and major complications). As our primary analysis showed, confounding factors such as age and BMI could also influence complications besides operation time. To determine the impact of these risk factors, the multivariate logistic regression model was fitted to evaluate the association between independent variables and the occurrence of complications (regardless of the complication grade) and demonstrated that operation time and BMI (OR = 1.04 and 0.85,

Table 2. A description of variables, divided in terms of the CDC.

Variables of interest	CDC			*p*-Value
	None	Minor	Major	
Sex (male), num. (%)	27 (87.1%)	61 (66.3%)	27 (79.4%)	0.055[a]
Size (mm), num. (%)				
15–20	15 (48.4%)	27 (29.4%)	10 (29.4%)	0.053[a]
20–30	11 (35.5%)	43 (46.7%)	13 (38.2%)	
30–50	5 (16.1%)	10 (10.9%)	3 (8.9%)	
>50	0 (0%)	12 (13.0%)	8 (23.5%)	
Operation time (min), median (IQR)	45 (40–60)	50 (45–65)	60 (55–75)	0.001[b]
Involved calyx				
1	20 (64.5%)	7 (51.1%)	17 (50.0%)	0.039[a]
2	11 (35.5%)	35 (38.0%)	9 (26.5%)	
⩾3	0 (0)	10 (10.9%)	8 (23.5%)	
BMI (kg/m^2) mean (SD)	26.1 (4.7)	23.1 (3.9)	22.8 (4.0)	0.001[c]
Duration of anesthesia (min), median (IQR)	120 (120–150)	120 (120–160)	120 (120–180)	0.203[b]
Age (year), mean (SD)	43.8 (12.5)	47.0 (12.3)	52.0 (12.7)	0.033[c]
ASA (⩾3), number (%)	16 (51.6%)	52 (56.5%)	24 (70.6%)	0.246[a]
CCMI (⩾1), number (%)	0 (0%)	65 (70.7%)	24 (70.6%)	<0.001[a]

[a]Chi-square test.
[b]Wilcoxon test.
[c]ANOVA test.

Table 3. Logistic regression models on complication occurrence.

Variables	OR (95% CI)	*p*-Value
Univariate		
Operation time (min)	1.04 (1.01, 1.06)	0.014
Duration of anesthesia (min)	1.01 (1.00, 1.02)	0.097
ASA (⩾3)	1.43 (0.65, 3.14)	0.379
CMMI (⩾1)	Model not fitted	
Age (year)	1.03 (1.03, 1.06)	0.074
Sex (male)	0.34 (0.11, 1.05)	0.060
Size (mm), (15–20 as reference)		
20–30	2.06 (0.85, 4.99)	0.107
30–50	1.05 (0.32, 3.48)	0.931
>50	Model not fitted	
Involved calyx (1 as reference)		
2	1.25 (0.55, 2.87)	0.598
⩾3	Model not fitted	
BMI (kg/m^2)	0.84 (0.75, 0.93)	0.001
Multivariate		
Operation time (min)	1.04 (1.01, 1.07)	0.003
Sex (male)	0.34 (0.10, 1.13)	0.078
Age (year)	1.02 (0.98, 1.06)	0.262
BMI (kg/m^2)	0.85 (0.77, 0.94)	0.002

Table 4. Logistic regression models on major complications.

Variables	OR (95% CI)	*p*-Value
Univariate		
Operation time (min)	1.03 (1.01, 1.05)	0.009
Duration of anesthesia (min)	1.01 (1.00, 1.02)	0.093
ASA (⩾3)	1.94 (0.86, 4.40)	0.112
CMMI (⩾1)	2.14 (0.94, 4.85)	0.068
Age (year)	1.04 (1.01, 1.07)	0.020
Sex (male)	1.53 (0.61, 3.85)	0.361
Size (mm), (15–20 as reference)		
20–30	1.01 (0.40, 2.53)	0.981
30–50	0.84 (0.20, 3.47)	0.810
>50	2.80 (0.90, 8.66)	0.074
Involved calyx (1 as reference)		
2	0.77 (0.32, 1.88)	0.237
⩾3	3.15 (1.08, 9.20)	0.036
BMI (kg/m^2)	0.95 (0.86, 1.04)	0.237
Multivariate		
Operation time (min)	1.03 (1.00, 1.05)	0.048
Analgesic duration (min)	1.00 (0.99, 1.01)	0.898
CCMI (⩾1)	1.90 (0.80, 4.48)	0.144
Age (year)	1.04 (1.00, 1.07)	0.031

respectively) significantly contributed to the occurrence of at least one complication. ROC for surgery time showed AUC of 0.631 and suggest that 65-min cut-off had a predictive value for complication occurrence (96.8% specificity and 31.0% sensitivity). As shown by analysis, this cut-off has a reasonable specificity for predicting complication occurrence, which means if the procedure lasts less than 65 min, most likely no complication happens. Subsequently, the same analysis was performed to find the association between variables and the occurrence of major complications. The results suggest that operation time (OR = 1.03) and age (OR = 1.04) are significantly associated with major complication occurrence. The AUC of ROC for operation time was 0.650 and the suggestive cut-off for prediction was 55-min with 76.5% sensitivity and

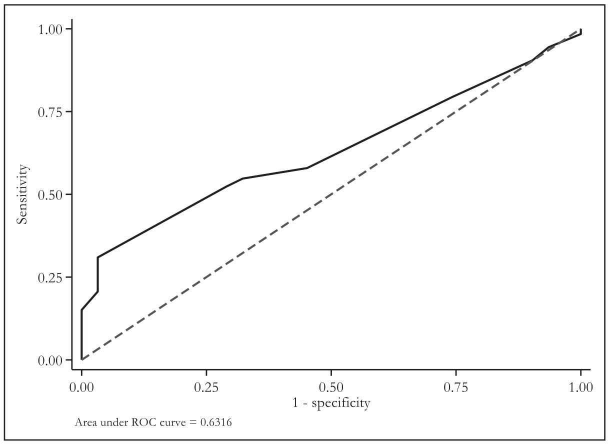

Figure 2. ROC curve for operation time performance in predicting complication after PCNL surgery.

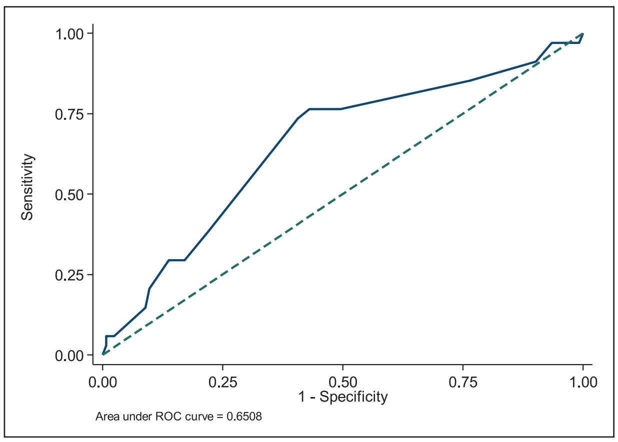

Figure 3. ROC curve for operation time performance in predicting major complications after PCNL surgery.

Table 5. Logistic regression models on SIRS.

Variables	OR (95% CI)	*p*-Value
Univariate		
Operation time (min)	1.02 (1.00, 1.04)	0.051
Duration of anesthesia (min)	1.01 (1.00, 1.02)	0.055
ASA (⩾3)	2.37 (1.23, 4.57)	0.010
CMMI (⩾1)	1.44 (0.76, 2.72)	0.262
Age (year)	0.98 (0.95, 1.00)	0.080
Sex (male)	0.89 (0.44, 1.80)	0.735
Size (mm), (15–20 as reference)		
20–30	2.48 (1.17, 5.23)	0.018
30–50	0.94 (0.30, 2.94)	0.921
>50	3.51 (1.19, 10.35)	0.023
Involved calyx (1 as reference)		
2	1.20 (0.60, 2.37)	0.609
⩾3	3.47 (1.13, 10.61)	0.029
BMI (kg/m^2)	0.97 (0.90, 1.04)	0.381
Multivariate		
Operation time (min)	1.01 (0.99, 1.03)	0.487
Duration of anesthesia (min)	1.01 (1.00, 1.02)	0.120
ASA (⩾3)	2.59 (1.31, 5.12)	0.006
Age (year)	0.97 (0.95, 1.00)	0.036

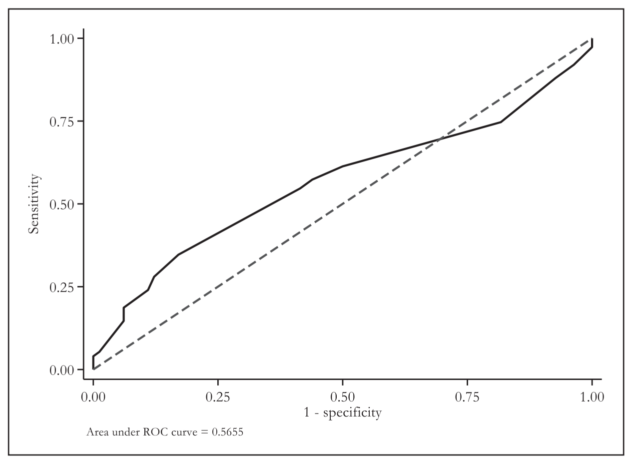

Figure 4. ROC curve for operation time performance in predicting SIRS after PCNL surgery.

56.9% specificity. Although the operation time has a borderline significance in predicting major complications (*p*-value = 0.048), the obtained cut-off does not have a good sensitivity and specificity for predicting major complications. Sugihara et al.[24] conducted a study to evaluate risk factors of severe adverse events after PCNL. One thousand, five hundred and eleven patients were enrolled and adverse events were described as mortality, postoperative medication use, and postoperative intervention need. The multivariate model showed an association between severe adverse events and operation time (OR: 4.72 for 120–179 min to 17.95 for ⩾300 min compared with ⩽119 min). In this study, minor complications were not considered and CDC was not used to categorize adverse events; however, the results give us a good insight into prolonged operation time and complication. In another study by Iqbal et al.[25] complication rates were assessed and compared between young and elderly patients. Findings revealed that complications occurred among 23.8% of all patients and were not significantly different between the two groups (24.07% in young vs 22.62% in elderly). These results are compatible with our findings which showed no association between age and complication occurrence (*p*-value = 0.262). In the Iqbal study, unfortunately, major complications were not statistically analyzed between the two groups; however, major complications (CDC grades 3, 4, and 5) were reported at 3.88% and 5.11% in the young and elderly, respectively, which was higher in the latter group. Our study analysis on major complications demonstrated a significant association in multivariate analysis between older age and major complications occurrence (*p*-value = 0.031 and OR = 1.04). A systematic review by Cheng et al.[11] assessed the association between operation time and complications across various surgical fields. They reviewed 68 studies, and the findings showed that 80% of studies reported significant results regarding increment of operation time on postoperative complications. The analysis revealed that a 1-min increment in surgery time increases the chance of complication by 1%. They also found out that the risk of complications doubled after 120 min.[11] Our study findings showed a 1-min increment of operation time leads to a 4% and 3% increase in overall and major complications, respectively.

The presence of large amounts of colonized bacteria, microenvironment formation due to urinary system obstruction, and high-pressure perfusion of washing fluid during the operation contribute to the high probability of infection. Following PCNL, about 21.0%–32.1% of the patients presented SIRS, and 0.3%–4.7% developed urosepsis. Urosepsis could lead to septic shock with a 20%–42% mortality rate if diagnosis is delayed. Adverse events of urosepsis would be minimized if we can effectively predict the risk of urosepsis and treat patients properly. Previous studies demonstrated that the identification of SIRS has a potential clinical privilege for the early diagnosis of sepsis.[26–28] Our study findings revealed that about 48% of patients were SIRS positive after PCNL, and operation time was not significantly different between patients who were SIRS positive, and those who were not (p-value = 0.051). Although borderline significance in univariate analysis, multivariate analysis also demonstrates that operation time was not associated with SIRS occurrence (p-value = 0.487); however, ASA score and age are associated with SIRS (OR = 2.59 and 0.97). Yang et al.[29] seek to find the risk factors for infectious complications after PCNL and found out that operation time was not identify as a risk factor (p-value = 0.971). In another study by Chen et al.,[30] bioinformatics data and clinical parameters were used to find predictors of urogenous sepsis. These findings also revealed that operation time was not associated with sepsis (p-value = 0.233).

In this study, we evaluate the influence of operation time on standard PCNL postoperative complications. The recently developed miniaturized percutaneous nephrolithotomy (mini-PCNL) utilizes a smaller-sized nephroscope, resulting in less damage to the renal parenchyma with similar therapeutic efficacy garnered significant attention in treating renal stones.[31] Thapa and Niranjan[32] performed a systematic review on comparison of the efficacy of PCNL and mini-PCNl. Stone free rate has been shown no significant differences, complication rates was fewer in mini-PCNL specially bleeding, and PCNL had a lower operation time. Although the standard PCNL instruments and techniques are modified gradually to reduce tract size and move toward the concept of miniaturization, standard PCNL still has a significant role in managing large and complex kidney stones. On the other hand, moving toward miniaturization needs certain surgical skills and the availability of special instruments.[33,34]

As tract size, surgical procedure, complication rate, and operation time are different among standard and miniaturized PCNL, some complications such as bleeding, need for angioembolization, and hemorrhagic shock may be attributed to these factors—which are not applicable in our study—so our results cannot be generalized to mini-PCNL. Further studies are encouraged to evaluate the effect of operation time and other confounding variables on mini-PCNL postoperative complications.

Another important consideration to note is that our center is a tertiary and educational hospital. These characteristics may influence the generalizability of our results. Therefore, it is imperative to conduct multicenter studies in noneducational settings to obtain a more precise insight into the effect of operation time on complications.

Finally, our study assesses the postoperative complications within the first month following PCNL. Studies with longer follow-up duration could give us a better insight into PCNL complications and its effect on renal function.

Conclusion

Complications after any procedures are attributed to many factors, some of which could be modulated such as operation time. Here, we discovered that operation time can associated with the complication occurrence (both overall complication and major complication) but revealed no association with SIRS. We also propose a 65-min cut-off for operation time according to our analysis with 96.8% specificity which means keeping the operation time less than 65 min can prevent complications. However, our perusal was a single-center study with a limited sample size and larger multicentric studies are needed to evaluate the impact of operation time on post-PCNL complications more precisely.

Acknowledgements

The authors would like to thank the Persian Registry for Stones of Urinary System (PERSUS). All authors would like to thank the Research Development Center of Sina Hospital for their technical assistance.

Author contribution

Amirreza Shamshirgaran: writing the manuscript draft. Alireza Pakdel, Abdolreza Mohammadi, Seyed Reza Hosseini, and Ehsan Zemanati Yar: validation and methodology. Farshid Alaeddini: data analysis. Roghayeh Koohi Ortakand and Leila Zareian Baghdadabad: running lab tests. Leonardo Oliveira Reis: editing and reviewing. Seyed Mohammad Kazem Aghamir: conceptualization.

Data availability

Data will be provided on request.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical considerations

The study protocol received approval from the ethics committee of Tehran University of Medical Sciences (IR.TUMS.SINAHOSPITAL.REC.1402.011). The study adhered to the principles outlined in the Helsinki Declaration.

Informed consent

Written informed consent from Persian Registry for Stones of Urinary System (PERSUS) was obtained from all subjects before the study.

Consent to participate

Patients were included in our study after signing the written informed consent from Persian Registry for Stones of Urinary System (PERSUS).

Consent for publication

All authors agree to publication.

Trial registration

Not applicable.

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