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Review

The global, prevalence, and risk factors of postoperative fever after percutaneous nephrolithotomy: A systematic review and meta-analysis

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Abstract *Objective:* This study aimed to explore the global, prevalence, and risk factors of fever after percutaneous nephrolithotomy (PCNL) by conducting a systematic review and meta-analysis.
Methods: The high-sensitivity searching was conducted without time limitation until December 30, 2020 in Web of Sciences, Scopus, and PubMed based on inclusion and exclusion criteria.
Results: The prevalence rates of fever and sepsis among patient undergoing PCNL were estimated 9.5% (95% confidence interval [CI]: 9.3%–9.7%), and 4.5% (95% CI: 4.2%–4.8%), respectively. Nephrostomy tube was used in 9.96% (95% CI: 9.94%–9.97%) of patients. The mean preoperative white blood cells of patients were 6.401×10^9/L; 18.3% and 4.55% of patients were considered as the positive urinary culture and pyuria, respectively. About 20.4% of patients suffered from residual stones. The odds ratios (ORs) of fever in patients who suffering from

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diabetes mellitus, hydronephrosis, staghorn stones, and blood transfusion were 4.62 (95% CI: 2.95—7.26), 1.04 (95% CI: 0.81—1.34), 2.57 (95% CI: 0.93—7.11), and 2.65 (95% CI: 1.62—4.35), respectively. Patients who underwent PCNL in prone position were more likely to develop fever (OR: 1.23; 95% CI: 0.75—2.00) than patients in supine position.

Conclusion: The current study showed that patients who suffer from diabetes mellitus, hydronephrosis, staghorn stones, nephrostomy tube or double-J stent, blood transfusion, and also patients who underwent PCNL in prone position surgery are more likely to develop a postoperative fever after PCNL.

1. Introduction

Urinary stones are the third most common disease after urinary tract infections (UTIs) and prostate diseases in the world. These stones are formed in the kidney, ureter, bladder, or urethra, but are commonly formed in the kidney and are known as kidney stones [1]. Kidney stones can cause complications such as urinary tract obstruction, back and abdominal pain, urinary blood, vomiting, painful urination, blood infection, and sometimes death. The prevalence rates of kidney stones in patients are estimated to be from 1% to 15%; however, these rates vary based on age, sex, race, and geographical location. The prevalence rates of kidney stones in men and women are 1.4% and 3.6%, respectively. Reports indicate that about three million visits are made annually to diagnose and treat urinary stones, and more than half a million people go to the emergency room because of urinary stone problems [2].

There are several methods for removing kidney stones. The percutaneous nephrolithotomy (PCNL) method is known as a minimally invasive method because adhesions and fibrosis, postoperative risks and disabilities, and patient's risk of death are less seen. However, research has shown that one in four PCNL patients may develop complications after PCNL. A slight to moderate increase in body temperature is one of the most common complications that usually occur immediately after surgeries. The cause of fever is often attributed to the release of inflammatory chemical mediators. Studies have shown that 21.0%—39.8% of patients experience UTIs and postoperative fever [3].

In the PCNL, even when urine is sterile (negative urine culture), the release of endotoxins of bacteria during stone fragmentation exposes the patient to septic complications. Studies have shown that 0.3%—9.3% of patients who underwent PCNL can potentially develop sepsis. Even implanting a nephrostomy tract can help release endotoxins of bacteria [3]. All endoscopic interventions in the field of urology can be considered contagious, even if there is no evidence of infection. Therefore, even if the urine is sterile, preoperative antibiotics are usually prescribed to prevent infections and their effects have been proven [4].

Despite the administration of preoperative antibiotics in patients with sterile urine culture, fever after PCNL is common and its prevalence rate has been reported up to about 37.0% [5]. In addition, factors such as positive preoperative urine culture, female gender, duration of operation, nephrostomy tube use, diabetes mellitus, chiropractic, type of stone, and history of PCNL surgery may increase the risk of fever [5—8]. However, studies not only have shown that diabetes mellitus patients are at higher risk of developing postoperative fever, but also have shown significant differences between the number of diabetes mellitus patients with and without postoperative fever [3,9]. It seems that another risk factor of postoperative fever after PCNL might be hydronephrosis, but there is controversial information about its effects on postoperative fever in patients who had undergone PCNL. Even though Rashid and Fakhuldin [10] showed that hydronephrosis increases the risk of postoperative fever, Mariappan and Tolley [6] have demonstrated that giving patients with large stones or hydronephrosis a one-week course of antibiotics before PCNL may decrease the risk of sepsis.

In this systematic review and meta-analysis, we aimed to investigate the odd ratio (OR) of factors such as patient gender, diabetes mellitus, hydronephrosis, and the type of staghorn stones in postoperative fever after PCNL. Evaluation of the causes of fever after PCNL can be a very effective step for surgeons in fever management, which will be addressed in this study.

2. Method

2.1. Study protocol

The present study is based on the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guideline [11] and the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement [12,13]. Approval ID of research ethics certificate is IR. GUMS.REC.1399.127 at Jul 1, 2020 in Guilan University of Medical Sciences. The PROSPERO code is CRD42020164291. This study was conducted in five steps including design and search strategy, a collection of articles and systematic review, evaluation of inclusion and exclusion criteria, qualitative evaluation, and statistical analysis of data. Two researchers (Keivanlou M-H and Jafari A) independently carried out all the steps; a specialist (Falahatkar S) assessed any encounters, if any.

2.2. Search strategy

The high-sensitivity search was carried out using standard keywords such as Mesh and Mesh Entry, and also all probabilistic word combinations were used by Boolean operators OR without time limitation until December 30, 2020 in international databases, such as Web of Sciences, Scopus, and PubMed. Each search was done separately with the following search terms: nephrolithotomy AND percutaneous, nephrolithotomies AND percutaneous, percutaneous nephrolithotomies, percutaneous nephrolithotomy, pyemia, pyemias, pyohemia, pyohemias, pyaemia, and pyaemias. English abstract was only used as a language filter.

2.3. Inclusion and exclusion criteria

2.3.1. Inclusion criteria based on population, intervention, comparison, outcome format (related to evidence-based medicine) [14]

Cohort studies and cross-sectional studies were included in this systematic review and meta-analysis in order to estimate the OR of risk factors in postoperative fever among PCNL patients. The population, intervention, comparison, outcome format included: (1) population: patients underwent PCNL; (2) intervention: super-mini-PCNL, mini-PCNL, ultra-PCNL, micro-PCNL, and standard-PCNL; complete supine-PCNL and prone-PCNL; (3) comparison: patients with or without postoperative fever; (4) outcome: OR of postoperative fever among patients with or without PCNL by performing a meta-analysis.

2.3.2. Exclusion criteria

The exclusion criteria included: (1) review articles, letters, comments, case reports, clinical trials, or conference proceedings; (2) studies that did not focus on the postoperative fever in PCNL patients; (3) duplicated papers; (4) non-English; (5) non-accessible full text.

2.4. Selection of studies

The papers were entered into the EndNote (Version 20.6, Clarivate Analytics, Philadelphia, PA, USA) after the search ended. The authors' names and their affiliations, journals' names and their publishing year were blinded. The titles of studies were skimmed and scanned by two researchers (Keivanlou M-H and Jafari A) independently based on inclusion criteria and exclusion criteria. A specialist (Falahatkar S) assessed any encounters if any and made the final decision.

2.5. Quality appraisal

The quality of the final studies was examined after excluding irrelevant studies in the screening and eligibility stages. The Newcastle-Ottawa Scale [15] checklist was used which consists of eight sections, and divides the studies with a scale score of 0–8 from poor to high-quality, respectively. According to this scoring, the studies were divided into three levels of scoring: (1) poor quality (studies with a score of <5); (2) medium quality (studies with a score of 5–6); (3) high quality (studies with a score of 7–8). Finally, medium and high-quality articles were entered into data extraction stage.

2.6. Data extraction

A checklist was developed based on the variables of the study. The checklist included information such as the name of the primary author, publication year, sample size, gender, age, stone size, stone burden, fever categorized by type of PCNL procedure (super-mini-, mini-, micro-, ultra-, and standard-PCNL), overall fever occurrence, sepsis occurrence, hospitalization, operative time, presence of nephrostomy tube, urine culture results, UTI, systemic inflammatory response syndrome (SIRS), type of stone (single, multiple, or staghorn), presence of residual fragments, septic shock, white blood cell count, presence of pyuria, and risk factors such as diabetes mellitus, hydronephrosis, blood transfusion, position during surgery (supine or prone), presence of nephrostomy tube or double-J stent, and presence of staghorn calculi. All data were extracted by Falahatkar R, Khajavi Gaskarei MA, Afzalipoor M, Aligolighasemabadi N, and Mirzaei Dahka S, independently. If extra raw data were needed, a request would have been sent to the correspondents.

2.7. Statistical analysis

A meta-analysis was done to compare the risk factors of PCNL in patients with fever. Extracted data for the meta-analysis included gender, age, stone size, stone burden, fever based on type of PCNL procedure (subgroup analysis of super-mini-, mini-, micro-, ultra-, and standard-PCNL), total fever, total sepsis, hospitalization, operative time, nephrostomy tube, urine culture, UTI, SIRS, type of stone (subgroup analysis of single, multiple, and staghorn), residual fragment, septic shock, white blood cell (WBC), and pyuria. OR and standardized mean difference were used to analyze binary variables such as diabetes mellitus, preoperative hydronephrosis, blood transfusion, supine or prone type of position (subgroup analysis of supine or prone position), nephrostomy tube or double-J stent, and staghorn calculi, and the continuous parameters. We performed our meta-analysis by comprehensive meta-analysis software (version 2.2.064, Biostat Inc., Tampa, FL, USA). The OR of variables was analyzed by 95% confidence interval (CI). The OR (greater than 1) showed an association (correlated). The I^2 index less than 25% was defined as low heterogeneity, and the I^2 index between 25% and 75% was defined as average heterogeneity, and the I^2 index more than 75% was considered as heterogeneous [16]. Heterogeneity among the studies was measured using the Chi-squared statistics ($p=0.05$); fixed effect models were considered for homogeneous data; and random effects analysis was calculated for heterogeneous data.

3. Results

3.1. Prevalence of postoperative fever and urinary sepsis after PCNL

3.1.1. Patient sample size

In this systematic study, based on the performed searches, 17 276 articles were identified, and 324 (1.88%) articles were entered into the final list after conclusive investigation and evaluation according to the checklist [17–24] (Fig. 1). The total sample size was estimated at 108 150 patients.

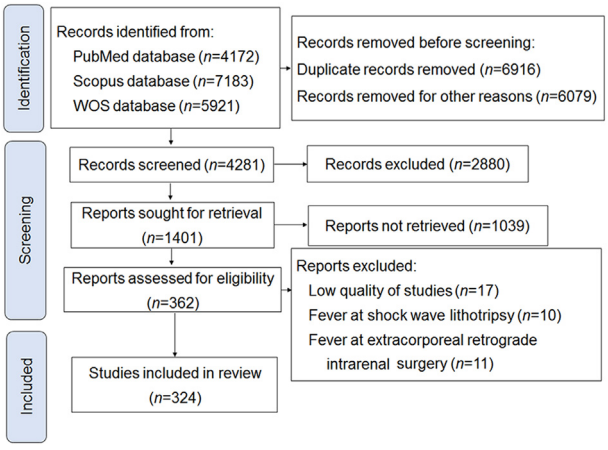

Figure 1 The flow diagram of Preferred Reporting Items for Systematic reviews and Meta-Analyses. WOS, Web of Science.

3.1.2. General clinical information

General clinical information showed that total mean age among patients with post-PCNL fever was 48.408 (95% CI: 48.406–48.411) years (Table 1). Regarding subgroup analysis, 57.6% (95% CI: 57.3%–58.0%) of patients with post-PCNL fever were male (Table 2), and 40.9% (95% CI: 40.5%–41.2%) were female (Table 2). The total mean operative time among patients with post-PCNL fever was 72.412 (95% CI: 72.410–72.413) min (Table 1). Also, we estimated that total mean of hospitalization among patients with post-PCNL fever was about 4.752 (95% CI: 4.571–4.574) days (Table 1).

Table 1 The variables in patients with postoperative fever.

Variable	Mean (95% confidence interval)	I^2 (%)
Age, year	48.408 (48.406–48.411)	99.99
Stone burden, mm^3	24.390 (24.370–24.400)	100.00
Stone size, mm	27.883 (27.882–27.884)	100.00
Duration of the operation, min	72.412 (72.410–72.413)	100.00
Hospitalization, day	4.572 (4.571–4.574)	99.99

Table 2 The variables of patients with post-PCNL fever.

Variable	Percentage (%)[a]	I^2 (%)
Gender		
Male	57.6 (57.3–58.0)	92.49
Female	40.9 (40.5–41.2)	90.54
Type of stone		
Multiple	43.5 (42.9–44.1)	98.12
Single	34.7 (34.0–35.3)	97.27
Staghorn	28.4 (28.0–28.9)	97.69
Type of PCNL procedure		
Super-mini-PCNL	12.0 (9.6–14.8)	78.77
Mini-PCNL	8.2 (7.9–8.6)	91.79
Ultra-PCNL	10.3 (9.7–10.9)	94.03
Micro-PCNL	5.2 (2.7–9.7)	94.23
Standard-PCNL	9.3 (8.9–9.6)	93.71
Total fever	9.5 (9.3–9.7)	92.60
Patient position during PCNL		
Prone	89.9 (88.7–91.0)	90.93
Supine	50.2 (46.2–54.1)	95.19
Sepsis	4.5 (4.2–4.8)	94.42
Septic shock	2.3 (1.7–2.9)	98.23
Nephrostomy tube	9.96 (9.94–9.97)	100.00
Residual stone	20.4 (20.0–20.8)	95.82
Positive urine culture	18.3 (17.8–18.8)	95.56
Urinary tract infection	27.6 (26.7–28.5)	97.95
Systemic inflammatory response syndrome	17.6 (16.5–18.8)	97.52
Country		
China	9.7 (9.4–10.0)	91.98
Egypt	9.0 (7.3–11.0)	60.23
India	12.1 (10.9–13.4)	84.44
Iran	13.8 (11.3–16.6)	71.58
Turkey	9.6 (8.9–10.0)	93.46
UK	1.8 (1.5–2.2)	60.98
USA	17.0 (13.8–20.9)	92.95
Republic of Korea	12.1 (10.4–14.0)	98.22
China (Taiwan)	12.3 (11.0–13.6)	65.59
Preoperative white blood cell, *n* (per microliter)		
$<$10 000 cells	8.24 (8.02–8.44)	97.84
$\geq$10 000 cells	1.72 (1.53–1.94)	97.68
Preoperative white blood cell ($\times 10^9$/L)	6.401 (6.400–6.402)	99.98
Pyuria	4.55 (4.43–4.67)	97.65

PCNL, percutaneous nephrolithotomy.
[a] Data are presented as mean (95% confidence interval).

3.1.3. Prevalence of post-PCNL fever and urinary sepsis at patients

Subgroup analysis of data demonstrated that 43.5% (95% CI: 42.9%–44.1%), 34.7% (95% CI: 34.0%–35.3%), and 28.4% (95% CI: 28.0%–28.9%) of patients with post-PCNL fever had multiple, single, and staghorn stones, respectively (Table 2). In this study, total mean stone size among patients with post-PCNL fever was estimated 27.883 (95% CI: 27.882–27.884) mm (Table 1). In this study, total mean stone burden among patients with post-PCNL fever was

estimated 24.390 (95% CI: 24.370–24.400) mm^3 (Table 1). The prevalence of fever among patients with post-PCNL fever was estimated 9.5% (95% CI: 9.3%–9.7%) (Table 2).

The mean preoperative WBC of patients was 6.401 (95% CI: 6.400–6.402) cells per microliters (Table 2). This study showed that 8.24% (95% CI: 8.02%–8.44%) and 1.72% (95% CI: 1.53%–1.94%) of patients had less than 10 000 cells per microliters and more than 10 000 cells per microliters of WBC, respectively (Table 2). The 4.55% (95% CI: 4.43%–4.67%) of patent with post-PCNL fever was considered as the pyuria (Table 2).

The highest prevalence postoperative fever was 17.0% (95% CI: 13.8%–20.9%) in the USA, 13.8% (95% CI: 11.3%–16.6%) in the Iran, and the lowest prevalence of postoperative fever was 1.8% (95% CI: 1.5%–2.2%) in the UK (Table 2). The prevalence rate of post-PCNL fever in other countries were shown in Table 2. Regarding subgroup analysis of data, the prevalence rate of fever among patients who underwent super-mini-PCNL was 12.0% (95% CI: 9.6%–14.8%). The prevalence rate of fever among patients who underwent mini-PCNL was 8.2% (95% CI: 7.9%–8.6%); ultra-PCNL was 10.3% (95% CI: 9.7%–10.9%); micro-PCNL was 5.2% (95% CI: 2.7%–9.7%); and standard PCNL was 9.3% (95% CI: 8.9%–9.6%) (Table 2).

The prevalence urinary sepsis among patients with PCNL in the world was estimated as 4.5% (95% CI: 4.2%–4.8%), and the prevalence of septic shock among patients with septic in the world was calculated as 2.3% (95% CI: 1.7%–2.9%) (Table 2). Nephrostomy tube was used in 9.96% (95% CI: 9.94%–9.97%) of patients (Table 2). The positive urinary culture in the patents with postoperative fever was 18.3% (95% CI: 17.8%–18.8%) (Table 2).

According to the findings of this research, it was observed that 27.6% (95% CI: 26.7%–28.5%) of patients who experienced post-PCNL fever exhibited clinical signs and symptoms of UTIs (Table 2). In current meta-analysis, SIRS was seen in 17.6% (95% CI: 16.5%–18.8%) among patients with post-PCNL fever in the world (Table 2). We found that 20.4% (95%: 20.0%–20.8%) of patients with PCNL in the world suffered from residual stones (Table 2). This current study showed that post-PCNL fever was seen in 89.9% (95% CI: 88.7%–91.0%) of patients who underwent PCNL in prone position, and 50.2% (95% CI: 46.2%–54.1%) of patients who underwent PCNL in supine position, respectively (Table 2).

3.2. Frequency of fever risk factors in patients after PCNL

3.2.1. General information of patients with or without fever after PCNL

In this study, the OR of less than 1 showed a negative correlation between male and female (OR: 0.62; 95% CI: 0.48 to 0.81). Current study showed that the female patients who underwent PCNL had a high chance of developing fever in comparison with the male. To analyze the OR of gender, the fixed effect method was used because the data were non-homogenous data (I^2=2.080) (Table 3; Supplementary Table 1).

3.2.2. The fever frequency at diabetes mellitus patients

Out of a total of 117 patients who suffered from diabetes mellitus, 53 (45.30%) patients had a postoperative fever after PCNL. Patients who suffer from diabetes were more likely to develop postoperative fever (OR: 4.62; 95% CI: 2.95–7.26). To analyze the OR of diabetes mellitus, the fixed effect method was used because the data were non-homogenous data (I^2=48.650) (Table 3; Supplementary Table 2).

3.2.3. The fever frequency in patients with hydronephrosis

Out of a total of 893 patients who suffered from hydronephrosis, 177 (19.82%) patients had a postoperative fever after PCNL. Patients who suffer from hydronephrosis were more likely to develop postoperative fever (OR: 1.04; 95% CI: 0.81–1.34). To analyze the OR of hydronephrosis, the fixed effect method was used because the data were non-homogenous data (I^2=0.000) (Table 3; Supplementary Table 3).

3.2.4. The fever frequency in patients with staghorn stones after PCNL

Out of a total of 96 patients who suffered from staghorn stones, 10 (10.42%) patients had a postoperative fever after PCNL. The results showed that PCNL patients with staghorn stones had a higher risk to postoperative fever (OR: 2.57; 95% CI: 0.93–7.11). To analyze the OR of staghorn stones, the fixed effect method was used because the data were non-homogenous data (I^2=66.350) (Table 3; Supplementary Table 4).

Table 3 The odds ratio analyses of fever in patients with diabetes mellitus, hydronephrosis, blood transfusion, nephrostomy tube or double-J stent, staghorn stones, and different types of position (supine or prone) after percutaneous nephrolithotomy.

Variable	Number of studies	95% CI	*p*-Value	I^2 (%)	Odds ratio	Supplementary tables
Gender (male/female)	7	0.48–0.81	0.000	2.080	0.62	S Table 1
Diabetes mellitus (yes/no)	5	2.95–7.26	0.000	48.650	4.62	S Table 2
Hydronephrosis (yes/no)	6	0.81–1.34	0.717	0.000	1.04	S Table 3
Staghorn stones (yes/no)	3	0.93–7.11	0.061	66.350	2.57	S Table 4
Blood transfusion (yes/no)	3	1.62–4.35	0.000	0.000	2.65	S Table 5
Nephrostomy tube or double-J stent (yes/no)	3	0.40–1.93	0.185	40.700	0.88	S Table 6
Position (supine/prone)	6	0.75–2.00	0.398	38.604	1.23	S Table 7

CI, confidence interval.

3.2.5. The fever frequency in patients with blood transfusion after PCNL

Out of a total of 113 patients who suffered from blood transfusion, 28 (24.78%) patients had a postoperative fever after PCNL. Patients who suffered from blood transfusion were more likely to postoperative fever (OR: 2.65; 95% CI: 1.62—4.35). To analyze the OR of blood transfusion, the fixed effect method was used because the data were non-homogenous data (I^2=0.000) (Table 3; Supplementary Table 5).

3.2.6. The fever frequency in patients with nephrostomy tube or double-J stent after PCNL

Out of a total of 200 patients who suffered from nephrostomy tube or double-J stent, 34 (17.00%) patients had a postoperative fever after PCNL. Current study showed that the patients with nephrostomy tube or double-J stent had a higher chance to post-PCNL fever than the patients without nephrostomy tube or double-J stent. To analyze the OR of nephrostomy tube or double-J stent, the fixed effect method was used because the data were non-homogenous data (I^2=40.700). Indeed, patients with nephrostomy tube or double-J stent were more likely to develop postoperative fever (OR: 0.88; 95% CI: 0.40—1.93) (Table 3; Supplementary Table 6).

3.2.7. The fever frequency in patients with postoperative PCNL in prone position and supine position

Indeed, patients with PCNL in prone position were more likely to postoperative fever (OR: 1.23; 95% CI: 0.75—2.00; p-value=0.398) than patients with PCNL in supine position (Table 3; Supplementary Fig. 7).

4. Discussion

In the management of large kidney stones, surgeons commonly have been using the PCNL procedure as a standard invasive intervention [10,25]. Postoperative fever following PCNL is a frequently encountered and significant complication of this procedure. Several crucial risk factors have been identified to be associated with the development of postoperative fever after PCNL. In this systematic review and meta-analysis, we attempted to investigate the global, prevalence, and risk factors of postoperative fever PCNL with variables such as gender, age, stone size, stone burden, fever based on type of PCNL procedure, total fever, total sepsis, hospitalization, operative time, nephrostomy tube, urine culture, UTI, SIRS, type of stone (subgroup analysis of single, multiple, or staghorn stone), residual fragment, septic shock, diabetes mellitus, preoperative hydronephrosis, blood transfusion, supine or prone type of position, and nephrostomy tube or double-J stent.

The current study showed that diabetes was able to increase postoperative fever in PCNL patients (OR: 4.62; 95% CI: 2.95—7.26). In agreement with the study, several studies have confirmed the impact of diabetes in postoperative fever development [3,10,26]. Patients who have suffered from long-term diabetes might result in reduced blood flow to their extremities, which increase the risks of infection. On the other hand, the high sugar levels in blood and tissue allow bacteria to grow and infections to develop more quickly [27]. In fact, high blood sugar from diabetes could affect the body's immune system impairing the ability of white blood cells to come to the site of infection, stay in the infected area, and kill bacteria. The researchers confirmed that because of the buildup of plaque in blood vessels associated with diabetes, the blood supply around the infection may receive a poor blood supply, further decreasing the body's ability to fight infections [27]. Furthermore, studies have shown that patients with high blood sugar from diabetes may be more severely affected by infection with *Streptococcus pneumonia* [27], and be more likely to be infected with *Pseudomonas aeruginosa* and *Rhizopus oryzae* [28].

Hydronephrosis is a swelling in one or both kidneys, and urine does not fully empty from the bladder. In these conditions, residual urine, due to UTIs may cause postoperative fever [29,30]. The current study showed that hydronephrosis had no significant effect on postoperative fever (OR: 1.04; 95% CI: 0.81—1.34). The results showed that patients who suffered from hydronephrosis were more likely to develop postoperative fever. Studies have shown that hydronephrosis could be correlated with postoperative fever after PCNL [26]. Li et al. [31] have reported significant effect of hydronephrosis on postoperative fever. Of course, postoperative fever after PCNL may be correlated with a degree of hydronephrosis (mild, moderate, or severe). This study indicated the degree of hydronephrosis is a risk factor for postoperative fever after PCNL [9,25].

The current study showed that the existence of staghorn stone was one of other risk factors for postoperative fever after PCNL (OR: 2.57; 95% CI: 0.93—7.11). Our results showed that patients with staghorn stone are more likely to develop postoperative fever after PCNL compared to patients without staghorn stone. Staghorn stone is most frequently composed of mixtures of magnesium ammonium phosphate (struvite) and calcium carbonate apatite. Staghorn stones are strongly associated with UTIs caused by organisms that produce the enzyme urease, which promotes the generation of ammonia and hydroxide from urea [32]. This alkaline urinary environment may become a nidus for repeated UTIs by the crystallization of struvite and the formation of exopolysaccharide biofilm with the incorporation of micro-proteins into the biofilms matrix [32]. Moreover, staghorn stones may cause damage to kidney parenchyma and function, and lead to potential sepsis [32,33].

Researchers have reported that staghorn stones usually cause upper urinary tract obstruction and UTI [34,35]. When the urinary tract is obstructed, the various strains of bacteria on the surface of the stones are colonized and grow in large numbers in the renal pelvis [36]. Our findings are consistent with the idea that when stones are crushed, a substantial release of UTI-causing bacteria and their toxins occurs. These toxins can then enter the bloodstream through the damaged renal pelvic mucosa, resulting in infection, fever, and potentially sepsis. [37,38]. Staghorn stones increase the chance of pulmonary infection caused by toxin backflow into the blood. Staghorn stones often complicate the operation, and also take a long operative time; therefore, the contact between the nephroscope and the renal pelvic mucosa increases during the lithotripsy process and the probability of damage to the renal pelvic

mucosa will be greater [39—41]. Moreover, extreme operation time will increase the absorption of an intraoperative perfusion fluid, which may increase the toxins of *Pseudomonas aeruginosa* and *Clostridium difficile* entering the human blood, which increases the chance of fever or sepsis after PCNL.

Haberal et al. [42] have reported that patients with staghorn stones and preoperative UTIs had a higher risk of SIRS and fever after PCNL, which is consistent with our findings. Despite staghorn stones could increase the operative time, they also could increase the propensity for bleeding because there is a greater manipulation during the procedure [3,43]. In agreement with at least one prior study, Akhavizadegan et al. [44] found that the use of a nephrostomy tract is associated with a 60% increased risk of postoperative fever. Although the reason for this finding is unclear, some authors have suggested that nephrostomy tract may simply be used in more complicated cases, rather than directly affecting the risk of infection [44].

Current study showed that the female patients who underwent PCNL had a higher chance to fever in comparison the male (OR: 0.62; 95% CI: 0.48 to 0.81). Foxman [45] confirmed that females are generally at greater risk of UTIs in comparison with men, which is consistent with our findings. However, Gutierrez et al. [3] found no relationship between the gender and risk of fever post-PCNL.

5. Conclusion

The current study showed that patients who suffer from diabetes mellitus, hydronephrosis, staghorn stones, nephrostomy tube or double-J stent, blood transfusion, and also patients who underwent PCNL surgery in prone position were more likely to develop a postoperative fever after PCNL.

Author contributions

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Conflicts of interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajur.2022.04.008.

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