Journal of Iranian Medical Council, Volume 6, Issue no. 4
http://dx.doi.org/10.18502/jimc.v6i4.13448

Original Article

Outcome of Tubeless Percutaneous Nephrolithotomy in Patients with Single Kidney; A Cross-Sectional Study

Majid Salasi[1], Robab Maghsoudi[2], Masoud Etemadian[1], Mohammad Yaghoobi[3], Farzam Mahmoodi[1], Kaveh Mehravaran[1] and Nasrollah Abian[4]*

1. Department of Urology, Hasheminejad Kidney Center, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
2. Department of Urology, Firoozgar Hospital, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
3. Takhte Jamshid Hospital, Alborz University of Medical Sciences (ABZUMS), Karaj, Iran
4. Department of Urology, 5 Azar Hospital, School of Medicine, Golestan University of Medical Sciences, Gorgan, Iran

Abstract

Background: While tubeless Percutaneous Nephrolithotomy (PCNL) is becoming more popular, there might still be doubt in performing it on single kidney patients. This study is performed to assess outcomes and complications of tubeless PCNL in patients with single kidney.

Methods: In this cross-sectional study, 134 single kidney patients who underwent tubeless PCNL for renal stones, were assessed for outcomes including stone-free rate, duration of operation, length of hospital stay, changes in serum creatinine and hemoglobin levels, bleeding, infectious complications, damage to adjacent organs, and mortality. These outcomes were compared based on age, sex, history of comorbidities, history of interventions for kidney stones and the number of accesses during the operation.

Results: Mean duration of operation was 139.14 minutes. Mean length of hospital stay was 2.59 days. In total, 11.9% of patients required intraoperative blood transfusion and 3.7% required ICU admission due to complications. The most common postoperative complications included fever, hematuria and UTI. Initial stone-free rate after surgery was 67.2% and two weeks later 76.9%. No mortality was reported. Postoperative serum creatinine levels increased slightly in short term, however, improved significantly in long-term. Comorbidities such as diabetes mellitus, hypertension, ischemic heart disease, and chronic kidney disease were associated with a higher incidence of minor and major complications of tubeless PCNL and a lower rate of stone-free rate.

Conclusion: Tubeless PCNL is a relatively safe, feasible and efficient method with acceptable complications in single kidney patients.

Keywords: Percutaneous nephrolithotomy, Renal stones, Tubeless PCNL, Single kidney

*** Corresponding author**

Nasrollah Abian, MD
Department of Urology, 5 Azar Hospital, School of Medicine, Golestan University of Medical Sciences, Gorgan, Iran
Tel: +98 912 0148750
Email: Naabian@gmail.com

Received: Oct 13 2022
Accepted: Apr 3 2023

Citation to this article:
Salasi M, Maghsoudi R, Etemadian M, Yaghoobi M, Mahmoodi F, Mehravaran K, et al. Outcome of Tubeless Percutaneous Nephrolithotomy in Patients with Single Kidney; A Cross-Sectional Study. *J Iran Med Counc.* 2023;6(4):679-88.

Introduction

Urolithiasis in single kidneys presents a significant management problem to endourologists, since any damage to the kidney or its drainage can cause significant complications (1,2). Repeated interventions can ultimately lead to kidney replacement therapy (3). Due to the absence of a functional opposite kidney, hypertrophy and dilatation of the single kidney occurs, which creates a higher risk of hemorrhagic complications (4). Optimal treatment for renal stones in patients with single kidney should be implemented with caution. Considering the stone size and kidney function in these patients, the invasiveness of PCNL should be balanced with the success rate of Ureteroscopy (URS) and Shock Wave Lithotripsy (SWL) (5).

Percutaneous Nephrolithotomy (PCNL) for single kidney stones can be a significant operative challenge (6). Although technically similar to PCNL in patients with two viable kidneys, more cases are at risk in case of perioperative complications (7). Possible complications include uncontrollable bleeding requiring embolization or even nephrectomy with subsequent need for renal replacement therapy (8). In addition, data on patient characteristics suggest that patients with a solitary kidney have a higher ASA (American Society of Anesthesiologists) score and are therefore at greater risk of anesthetic complications (9). Several randomized controlled trials and meta-analyses evaluating the safety and efficacy of tubeless PCNL have been published (10-12). A recent meta-analysis by Xun *et al* (10) published in 2017, consisted of 14 controlled clinical trials and 1148 patients. The results showed that tubeless PCNL was significantly associated with shorter hospital stay, faster time to return to normal activity, lower postoperative pain scores, decreased postoperative sedation requirements, and decreased urinary leakage. At the same time, no significant difference was reported in postoperative hemoglobin reduction, stone-free rate, postoperative fever, or need for blood transfusion.

Since there are no randomized controlled trials in this group of patients, endourologists use their clinical expertise and available resources to tailor the best management plan for patients with a single kidney. Moreover, due to the high importance of complications and stone recurrence rates in patients with a single kidney and despite high safety and cost-effectiveness of tubeless PCNL in the recent studies, the present study was conducted to investigate the results of tubeless PCNL in patients with single kidney.

Materials and Methods

In this retrospective study, patients with single kidney who underwent tubeless PCNL at Hasheminejad Kidney Center in Tehran between 2016 to 2021 were included. Sampling was performed by available census method.

Demographic data, patient history such as underlying diseases [Diabetes Mellitus (DM), high blood pressure (HTN), cardiovascular diseases, Chronic Kidney Diseases (CKD)], smoking state (lifetime smoking ≥100 cigarettes), opium use disorder (according to DSM-5 criteria), single kidney cause (nephrectomy, agenesis, *etc.*), accompanying kidney disorders, history of interventional procedures for the treatment of kidney stones, side of stone (left or right), the type of position of patients during the operation (prone or supine), the type of stone (staghorn or simple) and the size of stone were extracted from patients' records.

All surgeries were performed by endourology fellows under direct supervision of the attending. 18-gauge needle was used for puncture (s) under fluoroscopic guidance. The tract was then dilated by coaxial dilation to 12F followed by one-shot dilatation to place the 28F Amplatz sheath. Then rigid nephroscope was inserted and pneumatic lithotripter was used to break the stones. After stone removal, 4.8F double J stent was placed in all the patients but no nephrostomy was used.

The results of tubeless PCNL surgery including success rate (*i.e,* stone-free rate immediately after surgery and 2 weeks later by using sonography plus plain radiography, and stones less than 4 mm were considered insignificant); duration of operation; duration of hospitalization; intensity of pain based on the Visual Analogue Scale (VAS); and changes in serum creatinine level, Glomerular Filtration Rate (GFR) (using Cockcroft-Gault equation), and serum hemoglobin before and after the operation were assessed. Also, complications of PCNL tubeless surgery including the need for blood transfusion, hospitalization in the intensive care unit, fever, hematuria, Urinary Tract Infection (UTI), damage to adjacent organs consisting of colon, spleen, liver, pleura, infection, bleeding, urinary leakage, and

mortality rate were investigated.

Data analysis

Data were entered into SPSS version 25 software (IBM Corp, Armonk, New York, USA) and analyzed. Mean and standard deviation were used to express quantitative findings and frequency and percentage for qualitative ones. Kolmogorov-Smirnov test was utilized to check normal distribution of quantitative data. Spearman, repeated measures ANOVA, Mann-Whitney, Chi square and Fisher's exact tests were used to analyze the data. P below 0.05 was considered statistically significant.

Ethical considerations

The researchers were committed to the Helsinki Convention in all stages, and the participants' information was used without revealing their identities. Also, a written consent form was obtained from all the patients and no additional costs were imposed on them. Also, they had the right to withdraw from the study at any time without affecting their medical care.

Results

Descriptive analyses

In total, 134 patients with single kidney who underwent tubeless PCNL entered the study. Mean age of the patients was 48.92 ± 11.44 years (13 to 76 years). 101 patients (75.4%) were males. Baseline demographic characteristics of the study participants are presented in table 1.

123 patients (91.8%) had functional single kidney while 11 patients (8.2%) had anatomical one. The side of kidney stone was right in 85 patients (63.4%) and left in 49 (36.6%). The mean ± SD stone size was 3.81 ± 1.18 *cm* (2 to 8 *cm*). The most common sites of stones were pelvis (23.9%), lower calyx (16.4%), multiple calyces (14.9%), lower calyx and pelvis (14.2%), and middle calyx and pelvis (13.4%). In 96.3% of the patients, the stone was radiopaque.

To perform PCNL surgery, one access was created in 119 patients (88.8%) and two accesses in 15 patients (11.2%). In 117 patients (87.3%) subcostal access, in 2 (1.5 percent) intercostal access and in 15 (11.2%) both accesses were used. Operation characteristics and complications are depicted in table 2. Modified Clavien-Dindo grade 1 complication was observed in 63 patients (47%), grade 2 in 26 patients (19%), and grade 4 in 5 patients (3.7%).

Statistical analysis

Spearman test demonstrated a direct and significant relationship between age and post-op pain (r=0.175, p=0.043) as well as age and serum creatinine changes (r=0.175, p=0.043). Moreover, Mann-Whitney

Table 1. Characteristics of single kidney patients who underwent tubeless PCNL

Variable		Value
Age, year (Mean±SD)		48.92±11.44
BMI, kg/m^2 (Mean±SD)		26.90±2.25
Gender, n (%)	Male	101 (75.4%)
	Female	33 (24.6%)
Underlying diseases, n (%)	Type 2 diabetes mellitus	22 (16.4%)
	High blood pressure	55 (41%)
	Ischemic heart disease	21 (15.7%)
	Chronic kidney disease	10 (7.5%)
Cigarette smoking, n (%)		54 (40.3%)
Opium addiction, n (%)		15 (11.2%)

Table 2. Operation characteristics and complications of single kidney patients who underwent tubeless PCNL

Variables		Mean	SD
Operation duration, min		139.14	27.51
Hospitalization, day		2.59	1.12
Post-op pain, VAS		1.77	1.41
		Frequency	Percentage
Clavien-Dindo Grade 1	Hematuria	36	26.9%
	Fever	42	31.3%
	Wound site leakage	3	2.2%
	Urinoma	1	0.7%
Clavien-Dindo Grade 2	Intraoperative blood transfusion	16	11.9%
	UTI	16	11.9%
Clavien-Dindo Grade 4	Lung emboli	1	0.7%
	ICU admit	5	3.7%

Visual Analogue Scale (VAS).

test showed a significant difference between men and women in terms of mean of operation duration (142.57±26.66 *vs.* 127.64±27.81, respectively, p=0.007) and hemoglobin changes (2.76±1.78 *vs.* 2.07±1.12, respectively, p=0.029). Furthermore, Mann-Whitney test showed that there was a higher operation duration, length of hospitalization and pain intensity between patients with and without DM (153.18±28.18 *vs.* 136.22±26.70, p=0.010, 3.77±1.11 *vs.* 2.36±0.98, p<0.001, 2.95±1.49 *vs.* 1.52±1.28, p<0.001, respectively), CKD (158.00±29.55 *vs.* 137.72±26.79, p=0.027, 4.50±1.58 *vs.* 2.44 ± 0.93, p<0.001, 3.40 ± 1.89 *vs.* 1.64±1.30, p=0.003, respectively), opium addiction (159.67 ± 18.84 *vs.* 136.55±27.40, p=0.001, 3.47±1.12 *vs.* 2.48±1.08, p<0.001, 3.93±1.48 *vs.* 1.50±1.15, p<0.001, respectively), previous PCNL history (151.75±26.91 *vs.* 136.93±27.13, p=0.009, 3.725±1.20 *vs.* 2.47±1.07, p<0.001, 2.55±1.63 *vs.* 1.63±1.33, p=.010, respectively) and HTN (147.45±26.95 *vs.* 133.35±26.55, p=0.001, 3.04±1.42 *vs.* 2.28±0.71, p<0.001, 2.24±1.53 *vs.* 1.44±1.28, p=0.001, respectively).

Moreover, Mann-Whitney test indicated higher operation duration and pain intensity in smokers (145.09 ± 22.78 *vs.* 135.13±29.75, p=0.009, 2.24±1.60 *vs.* 1.45±1.19, p=0.002, respectively). Furthermore, patients who needed two access sites had significantly higher operation duration (166.67±35.89 *vs.* 135.67±24.32, respectively, p= 0.001), hospitalization (3.73±1.16 *vs.* 2.45±1.03, respectively, p<0.001), post-op pain (3.73±1.15 *vs.* 1.56±1.12, respectively, p<0.001), perioperative blood transfusion (53.3 *vs.* 6.7%, respectively, p<0.001), fever (73.3 vs. 26.1%, respectively, p<0.001), hematuria (73.3 *vs.* 21% respectively, p<0.001), UTI incidence (33.3% *vs.* 9.2%, respectively, p=0.007), SFR at first post-operation day (13.3 *vs*. 76.5%, respectively, p<0.001) and two weeks later (20 *vs.* 84%, respectively, p<0.001) in comparison with patients with one access site. Hemoglobin changes were significantly more prominent in patients with functional single kidney compared to anatomical ones (2.68±1.68 *vs.* 1.57±1.11, respectively, p=0.024).

In addition, Spearman test showed a significant relationship between stone size and the duration of operation (r=0.405, p<0.001), stone size and hospital stay (r=0.371, p<0.001) and stone size and patients' pain scores (r=0.462), p<0.001).

In this study, serum creatinine and GFR were measured at three checkpoints, before and immediately after PCNL surgery (post operation day 1), and at the last follow-up (two months after the operation), and serum hemoglobin was measured twice before and immediately after PCNL surgery. The results of the repeated measures of ANOVA test indicated

that postoperative serum creatinine levels increased slightly in short term, however, improved significantly in long-term ($p<0.001$). Serum Creatinine level and GFR changes are shown in figures 1 and 2.

Discussion

One of the most challenging issues in urology is treatment of renal stones in patients with single kidney. Untreated stones are likely to diminish renal function and cause life-threatening sepsis (13). According to AUA guidelines, PCNL is characterized by an SFR of 74 to 83%, a transfusion requirement rate of 14 to 24%, an acute complication rate of 15%, and an additional treatment rate of 18% (14). Although standard PCNL is a known safe and effective treatment for renal stones, it can be associated with significant complications such as uncontrolled bleeding, sepsis, damage to the urinary collection system and adjacent viscera, and even kidney loss. Transfusion rates have been reported from 0.8 to 45% (15). In an effort to shorten hospital stay and reduce postoperative pain, the use of smaller caliber nephrostomy tubes (16,17) and tubeless PCNL have been evaluated by several groups (11).

Bellman *et al* studied tubeless PCNL in a selected group of patients who underwent antegrade endopyelotomy (18). After this report, several other investigators confirmed that tubeless PCNL resulted in shorter hospital stay and less postoperative pain (19,20) and lower expenses were compared to nephrostomy tube drainage (18,21). While most studies have used ureteral stents in patients undergoing tubeless PCNL, other investigators have recommended a "completely tubeless" approach (8,22).

The average length of operation and length of hospital stay in our study were 140 minutes and 2.5 days, respectively. In similar studies, the average operation time ranged from 65 to 138 minutes and the average length of hospital stay was 2 to 5.6 days (9,23-25).

In our study, the average postoperative pain was 1.77 based on the VAS scale. In Bhat *et al*'s study (25), the pain score of patients in standard, tubeless and

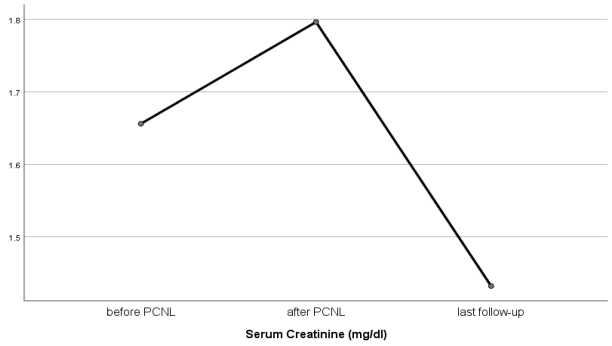

Figure 1. Mean serum Creatinine level of single kidney patients who underwent tubeless PCNL at three study points.

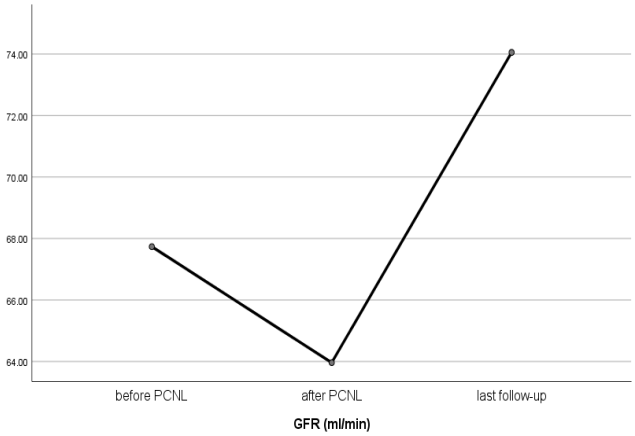

Figure 2. Mean GFR of single kidney patients who underwent tubeless PCNL at three study checkpoints.

completely tubeless PCNL techniques were reported as 6.64, 4.76 and 3.04, respectively, which showed a significant decrease in tubeless approach compared to the standard one. Besides, in Marchant *et al*'s study (26), although the VAS score on the first day was not different between the standard and tubeless methods, the scores on the second and third days were significantly lower in the tubeless group.

Examining the complications of tubeless PCNL in our study revealed that 11.9% of the patients needed blood transfusion and 3.7% needed hospitalization in ICU. In other studies, transfusion rates varied from 4.6 to 18.5% (9,24,27). In the study of Agrawal *et al* (28), in both standard and tubeless PCNL methods, no blood transfusion was needed. In Bhat *et al*'s study (25), the rate of blood transfusion in tubeless methods was reported to be twice than that of the standard method (4 *vs*. 8%).

In our study, the frequency of other postoperative complications, including fever, hematuria, UTI, urinary leakage, urinoma, and pulmonary embolism, were reported as 31.3, 26.9, 11.9, 2.2, 0.7, and 0.7%, respectively. Moreover, wound site infection and bleeding from the wound site, intra-abdominal viscera damage, sepsis, AV fistula, pseudoaneurysm, hemothorax and pneumothorax were not observed.

In the meta-analysis by Chen *et al*, tubeless PCNL was not associated with a significant reduction in fever recurrence (29). In another meta-analysis, there was no statistically significant difference between tubeless PCNL and standard PCNL regarding the rate of fever (30).

Examining laboratory changes in our patients showed a significant decrease in the amount of serum hemoglobin after surgery. El-Tabey *et al* (31) demonstrated that single kidney is an important risk factor for bleeding, as compensatory hypertrophy of the renal parenchyma is a physiological response to the single kidney. Uncontrolled bleeding may require angioembolization or even nephrectomy (32). However, in our study, no significant bleeding occurred and none of the patients required angioembolization.

There is a debate on whether PCNL has a potential effect on single kidney function. Streem *et al* (33) reported that serum creatinine was not different in one month in patients who underwent single kidney PCNL. Furthermore, Canes *et al* (34) reported that renal function was preserved or even slightly improved and GFR levels were significantly increased one year after PCNL. In Huang's study (35), a significant improvement in serum creatinine and GFR was observed from preoperative period to one month follow-up. In the current study, a slight increase in serum creatinine level was found on the first day after the operation compared to the values before the operation. However, longer follow-up showed that creatinine level and GFR returned to normal, and then significantly improved following tubeless PCNL.

In our study, the SFR of patients immediately after the operation and 2 weeks later were 67.2 and 76.9%, respectively. Mortality rate of the patients was nil. In other studies, regarding the outcomes of standard PCNL on single kidneys, the lowest and highest initial SFR had been reported as 65.4% (9) and 91.3% (8). Considering the comparison of SFR between standard and tubeless PCNL, in one meta-analysis (29), there was no difference in SFR between the two methods, while in another meta-analysis (30), the results showed that tubeless PCNL was slightly superior to standard PCNL in terms of SFR.

Other results of our study revealed that presence of comorbidities such as DM, HTN, ischemic heart disease and CKD were not only associated with more minor and major complications of tubeless PCNL. In contrast, smoking did not appear as a risk factor for increased complications and decreased SFR, however, opiate users showed higher rates of operative complications and lower rates of SFR. In the study conducted by Yuan *et al* (30), variables considered as risk factors for infectious complications after PCNL included female gender, stone size, and DM. Stone size is a risk factor that has been extensively described in several studies (36,37). Other studies pointed to DM as a risk factor for post-operative complications (38,39). It is well known that DM involves immunosuppression and is known as a risk factor for developing recurrent urinary tract infections (40). Du *et al* (41) reported a higher risk of severe bleeding after PCNL in patients with DM, while another study (42) showed a contrary finding.

On the other hand, our study demonstrated that with an increase in the number of access routes, the incidence of complications including intraoperative bleeding and hematuria and infectious complications

such as fever and UTI increased. Besides, an increase in the number of accesses was associated with a decrease in the operation success and SFR rate. Nevertheless, Hegarty and colleagues reported similar complication rates for single-tract and multi-tract accesses (43)They stated that multipuncture was not a significant factor for predicting grade IIIa and higher complications (43). In other investigations, the number of tracts had no significant effect on the complications of staghorn stones or in pediatrics (44,45). However, Netto *et al* reported a higher complication rate for multiple accesses compared to accesses of the upper pole and lower/middle calyces in staghorn stones (46). In another study, multiple tracts predicted higher complications in the modified Clavien-Dindo system. Most of the complications in this study were related to vascular events, bleeding and blood transfusions (47). It might be concluded that multitract approach is associated with increased blood loss and transfusion (48).

Our study had some limitations. The first and the most important one was its descriptive nature. The absence of a control group in this study, which could include the use of PCNL in patients with single kidney, the use of tubeless PCNL in patients with normal kidneys, or both, make the generalization power of our study limited. On the other hand, one of the advantages of this study was the relatively suitable number of samples and a thorough investigation of complications as well as initial and final assessment of SFR in patients.

Conclusion

Tubeless PCNL was a relatively safe, feasible and efficient method with satisfactory SFR and acceptable complications in the management of renal stones in patients with single kidney. Renal function in most patients undergoing tubeless PCNL with a single kidney deteriorated slightly in short-term follow-up, but improved significantly in long-term follow-up. Therefore, it is recommended to use this method along with a control group, to more closely examine the effectiveness and safety of tubeless PCNL in this group of patients.

Acknowledgements

This study was approved by the ethics committee of Iran University of Medical Sciences, Tehran, Iran (Code: ir.iums.smd.rec.1400.143).

Disclosure

None.

Funding and support

This study was supported by Iran University of Medical Sciences as part of a thesis to obtain specialty degree in urology.

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