

Ultrasound-guided percutaneous nephrolithotomy without indwelling ureteral catheter in older adults with upper urinary calculi

A retrospective study

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Abstract

Retention of ureteral catheter to establish artificial hydronephrosis is a routine step of percutaneous nephrolithotomy procedure, which can improve the success rate of puncture, but it can prolong the procedure time and increase the risk of postoperative infection, especially for immunocompromised elderly patients. Therefore, this study aims to investigate the safety and effectiveness of ultrasound-guided percutaneous nephrolithotomy without indwelling ureteral catheter for older patients with upper urinary calculi. The clinical data of 119 older patients admitted to the Affiliated Hospital of Jining Medical University for percutaneous nephrolithotomy from January 2019 to December 2021 were retrospectively analyzed. The patients were divided into study and control groups according to whether the physician decided to use ureteral catheter during the procedure, and the differences in the success rate of one-time puncture, operative time, single-stage stone removal rate, postoperative hospital stay, and complication rate were compared between the 2 groups. There were no significant differences in the success rate of one-time puncture and single-stage stone removal rate between the 2 groups ($P > .05$). The operation time were significantly shorter in the study group [(30.0–61.0) minute vs (54.8–106.8) minute, $P = .00$], and the intraoperative bleeding was less in the study group [(5–20) mL vs (10–30) mL, $P = .03$]. The postoperative hospital stay was shorter in the study group [(2.5–4.0) days vs (3.0–5.0) days, $P = .00$], and the medical expenses were lower in the study group [(17,309.5–22,652.7) yuan vs (19,148.0–24,407.6) yuan, $P = .02$]. The incidence of systemic inflammatory response syndrome was lower in the study group (3.5% vs 19.4%, $P = .007$). There were no statistically significant differences in complications such as postoperative fever, renal artery embolism and blood transfusion between the two groups ($P > .05$). Ultrasound-guided percutaneous nephrolithotomy without indwelling ureteral catheter for elderly patients with upper urinary stones is safe and feasible.

Abbreviations: CT = computed tomography, PCNL = percutaneous nephrolithotomy, SIRS = systemic inflammatory response syndrome.

Keywords: artificial hydronephrosis, older adults, percutaneous nephrolithotomy, urinary tract stones

1. Introduction

Worldwide, the increase in life expectancy has led to a higher incidence of renal calculi in the in the older adult population.^[1] Although percutaneous nephrolithotomy (PCNL) is an important tool for the treatment of complex upper urinary calculi,^[2] the associated complications include bleeding and infection. To improve the procedural success rate of PCNL, a ureteral catheter is routinely inserted retrogradely to create artificial

hydronephrosis, but this step increases the procedural duration and the risk of infection. Moreover, older patients, among whom the majority have chronic diseases, such as cardiac or pulmonary conditions, have reduced tolerance to anesthesia and surgery; prolonged operative time and excessive surgical stimulation in this vulnerable population can increase the risk of related complications.^[3] Therefore, this study was conducted to investigate the need for artificial hydronephrosis during PCNL in the older population.

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The authors have no conflicts of interest to declare.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The study protocol was approved by the ethics committee of the Affiliated Hospital of Jining Medical University.

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2. Methods

2.1. Study design and participants

The ethics committee of the Affiliated Hospital of Jining Medical University approved this study. In this study, we retrospectively enrolled 119 older patients admitted to the Department of Urology in the Affiliated Hospital of Jining Medical University between January 2019 and December 2021. The inclusion criteria included: upper ureteral calculi, multiple renal pelvis and calyceal calculi diagnosed by abdominal computed tomography (CT); age ≥ 60 years; and intervention through PCNL. Patients with incomplete clinical data were excluded. The patients were divided into study and control groups according to whether the physician decided to use ureteral catheter during the procedure. All participants completed a preoperative routine examination and routinely received preoperative antibiotic prophylaxis. Patients with urinary tract infection received symptomatic treatment according to the drug sensitivity results and underwent surgery after the infection subsided. For patients with chronic diseases, such as coronary heart disease and diabetes, surgery was performed after a positive preoperative evaluation.

2.2. Clinical data

The preoperative data that were collected included imaging and baseline characteristics, including sex and age. The type (single, multiple, or staghorn), and size of calculi were determined on ureteral CT imaging. Details such as the success rate of one-time intraoperative puncture, operative time, and intraoperative blood loss were collected. A complete ureteral CT was repeated 2 to 3 days after surgery to assess the calculi status. Postoperative complications, such as fever, systemic inflammatory response syndrome (SIRS), blood transfusion and renal artery embolization were recorded. The basic patient information, test results and surgical data were obtained from our electronic medical record database. Surgical time is defined as the time from the first disinfection to the closing suture; calculi size was defined as the sum of the maximum diameter of the measured calculi; residual calculi ≤ 4 mm was defined as clinically insignificant residual stones^[4]; and fever was defined as a temperature $\geq 38.0^{\circ}\text{C}$.

2.3. Surgical procedure

Surgery was performed with the patient under intravenous and inhalational compound anesthesia; participants in the study group underwent a urinary catheter insertion and were placed in the prone position. The puncture site was located between the 11th intercostal or the 12th costal from the subscapular angle to the posterior axillary line. Based on the preoperative CT and intraoperative ultrasound imaging, the target renal calyces are selected and punctured with an 18G puncture needle; then, a 0.032-mm guide wire was placed into the selected target renal calyx, and a one-shot dilation method was used for channel expansion. The percutaneous tract was then dilated to 18F or 20F using fascial dilators, and a peel-away sheath of the same size was inserted as the percutaneous access port. In the control group, a 5F ureteral catheter was inserted retrogradely through the ureteroscopy with the patient in the lithotomy position. Next, the patient was placed in the prone position, and saline was injected retrogradely through the ureteral catheter to create temporary artificial hydronephrosis. The puncture channel was established with the same method. After the channel was successfully established, a ureteroscopy was inserted, and the calculi was broken by Holmium laser or/and pneumatic ballast and flushed out using an injection pump; a double-J tube was placed postoperatively. All patients underwent CT imaging 2 to 3 days after surgery to evaluate the single-stage stone removal rate, and the double-J tube was removed after 1 month.

2.4. Statistical analysis

SPSS 26.0 was used for data analysis. The Shapiro–Wilk test was used to determine whether the continuous variables were normally distributed. Accordingly, data with normal distribution are presented as mean \pm standard deviation, whereas data with non-normal distribution are presented as the median and the 25th to 75th percentile. An independent *t*-test was used to compare two independent sets of normally distributed data, whereas the Mann–Whitney *U*-test was used for non-normally distributed data. Categorical data are expressed as number and percentage, and the frequencies of categorical variables were compared using the Pearson chi-square test. $P < .05$ was considered indicative of statistically significant differences.

3. Results

3.1. Participant demographics and calculi-related characteristics

The study group comprised 28 men and 29 women, and the mean age was 65.7 years. The control group included 34 men and 28 women, the mean age was 66.3 years. The calculi measured 3.5 and 3 cm in the study and the control group ($P = 0.29$). There were no statistically significant intergroup differences in baseline characteristics, such as calculi characteristics (size and type), comorbidities, grading of hydronephrosis. Participant demographics and preoperative characteristics are summarized in Table 1.

3.2. Surgical data and postoperative complications

There was no significant intergroup difference in the success rate of one-time puncture and single-stage stone removal rate ($P > .05$). The operation time was significantly shorter [(30.0–61.0) minute vs (54.8–106.8) minute, $P < .001$], the intraoperative bleeding was less [(5–20) mL vs (10–30) mL, $P = .03$], the postoperative hospital stay was shorter [(2.5–4.0) days vs (3.0–5.0) days, $P < .001$], and the medical expenses were lower [(17,309.5–22,652.7) yuan vs (19,148.0–24,407.6) yuan, $P = .02$] in the study group.

Furthermore, the incidence of SIRS was lower in the study group (3.5% vs 19.4%, $P = .007$). Two and five patients developed fever postoperatively in the study group and the control group, and improved with symptomatic treatment; no patient progressed to infectious shock. There were no statistically significant intergroup differences in complications such as postoperative fever, renal artery embolization, and blood transfusion ($P > .05$). Surgical data and postoperative complications are summarized in Table 2.

4. Discussion

PCNL has become one of the main treatment methods for complex calculi, but also carries the risk of complications, such as bleeding, infection, and renal failure.^[5] Precise puncture of the target renal calyces is one of the crucial steps for improving the success rate of puncture, and the conventional PCNL necessitates artificial hydronephrosis to dilate the target calyces to reduce the damage to the renal parenchyma and perinephric vessels during puncture and to lessen intraoperative bleeding. However, this leads to longer operation time, and retrograde perfusion of high pressure can increase the risk of urinary tract infection.^[6] Moreover, older patients have multiple comorbidities and poor immunity, which can easily lead to postoperative complications such as sepsis.^[7] Therefore, the need for artificial hydronephrosis needs to be explored in older patients.

The establishment of artificial hydronephrosis during routine PCNL can reduce the risk of puncture injury, but it requires a retrograde indwelling ureteral catheter and changes in the

Table 1**Demographics and calculi-related characteristics of patients.**

Variable	Study group (n = 57)	Control group (n = 62)	t/z/X ²	P-value
Gender, n (%)			0.38	.53
Male	28 (49.1)	34 (54.8)		
Female	29 (50.9)	28 (45.2)		
Age (years), mean ± SD	65.7 ± 4.5	66.3 ± 4.8	-0.68	.49
BMI (kg/m ²), mean ± SD	24.5 ± 4.0	23.9 ± 3.0	0.90	.36
Multiple stones length diameter (cm): median (IQR)	3.5 (2.3–5.4)	3.0 (2.3–5.0)	-1.05	.29
Type of calculi, n (%)			1.32	.51
Solitary	31 (54.4)	32 (51.6)		
Staghorn	16 (28.1)	14 (22.6)		
Multiple	10 (17.5)	16 (25.8)		
Diabetes, n (%)	8 (14.0)	10 (16.1)	0.10	.75
Coronary heart disease, n (%)	7 (12.3)	6 (9.7)	0.20	.64
Hypertension, n (%)	25 (43.9)	25 (40.3)	0.15	.69
Hydronephrosis grade, n (%)			2.03	.56
No	13 (22.8)	18 (29.0)		
Mild	15 (26.3)	14 (22.6)		
Moderate	12 (21.1)	17 (27.4)		
Severe	17 (29.8)	13 (21.0)		

BMI = body mass index, IQR = inter quartile range, SD = standard deviation.

Table 2**Comparison of surgical data and postoperative complications between the study and control groups.**

Variable	Study group (n = 57)	Control group (n = 62)	t/z/X ²	P-value
Success rate of one-time puncture, n (%)	51 (89.4)	55 (88.7)	0.01	.89
Single-stage calculi removal rate, n (%)	48 (84.2)	52 (83.9)	0.00	.96
Mean operative time (min): median (IQR)	40 (30.0–61.0)	75 (54.8–106.8)	-5.17	.00
Mean intraoperative bleeding (mL): median (IQR)	10 (5–20)	20 (10–30)	-2.14	.03
Mean postoperative hospitalization time (d): median (IQR)	3 (2.5–4.0)	4 (3.0–5.0)	-4.43	.00
Medical expense (yuan): median (IQR)	19,321.6 (17,309.5–22,652.7)	21,108.0 (19,148.0–24,407.6)	-2.31	.02
Postoperative fever rate, n (%)	2 (3.5)	5 (8.1)	1.11	.29
Postoperative renal artery embolism rate, n (%)	1 (1.8)	0 (0.0)	1.09	.29
Postoperative blood transfusion rate, n (%)	1 (1.8)	2 (3.2)	0.26	.60
SIRS, n (%)	2 (3.5)	12 (19.4)	7.18	.007
Sepsis, n (%)	0 (0.0)	0 (0.0)	1.00	.00

IQR = inter quartile range, SIRS = systemic inflammatory response syndrome.

patient's position twice, which can prolong the operation time and also result in damage to the ureteral mucosa when the ureteral catheter is left in situ.^[8] Furthermore, older patients have varying degrees of atherosclerosis and poor self-regulation,^[9] and intraoperative position changes are likely to induce orthostatic hypotension,^[10] in addition to the potential risk of limb and head and neck injuries during position changes. Based on the drawbacks of this operation, studies have demonstrated the safety of exempting indwelling ureteral catheters. Yeh et al^[11] showed that in patients with a pelvic dilatation width greater than 5 mm, no artificial hydronephrosis was created, and this did not decrease the success rate of puncture or increase intraoperative bleeding. Eryildirim et al^[8] demonstrated that in patients with moderate to severe hydronephrosis, the creation of artificial hydronephrosis did not reduce the time of puncture [(5.76 ± 2.45) minute vs (5.28 ± 2.08) minute, $P = .4909$]. Although preliminary studies have proved its safety, no study has demonstrated the safety of PCNL without indwelling ureteral catheter in the older population. We selected 119 older patients (age > 60 years) in this study; and 57 older patients without an indwelling ureteral catheter did not have a decreased success rate of puncture (89.4% vs 88.7%, $P = .89$) or increased intraoperative blood loss (10 mL vs 20 mL, $P = .03$) or blood transfusion rate (1.8% vs 3.2%, $P = 0.60$). Only one patient in the study group had delayed postoperative bleeding and was treated with renal artery embolization, whereas 2 patients in the study group had excessive intraoperative bleeding, and

normalized after blood transfusion. In addition, in this study, the intraoperative bleeding was significantly lower in the study group, which was mainly related to the short operation time. Therefore, we believe that the creation of artificial hydronephrosis during the operation did not increase the success rate of puncture and decrease the incidence of complications related to bleeding.

The immune capacity of elderly patients gradually declines with the increase of age, and renal arteriosclerosis and renal blood flow reduction are common, which increases the susceptibility to bacteria and easily leads to the occurrence of postoperative infection.^[12] Nakamon et al^[13] showed that the incidence of postoperative sepsis in older patients was significantly higher than that in young patients (6.65% vs 1.30%, $P = .007$). In addition, most studies showed that postoperative infection may be related to infectious stones, repeated urinary tract infection, long operation time, and other factors.^[14,15] In this study, postoperative fever was lower in the observation group (3.5% vs 8.1%, $P = 0.29$), but no significant difference was detected, and no patient progressed to sepsis. However, the incidence of postoperative SIRS was significantly higher in the control group (3.5% vs 19.4%, $P = .007$), which was attributed to the high pressure of retrograde perfusion leading to bacterial entry into the blood and aggravated the degree of infection during the establishment of artificial hydronephrosis in the control group. In addition, for patients without hydronephrosis, continuous bolus injection of fluid is often required to expand

the target calyx, which also increases the incidence of postoperative infection. Therefore, we believe that it is relatively safe to avoid artificial hydronephrosis in PCNL for older patients with upper urinary tract stones, especially for patients with infectious stones, preoperative urinary tract infection and long operation time, which can effectively reduce postoperative infection and the occurrence of SIRS.

Older patients have a long history of smoking and chronic respiratory diseases, and poor lung function, which can easily lead to postoperative pulmonary infection,^[16] and the length of surgical anesthesia is one of the factors that affects postoperative pulmonary infection.^[17] In the study group, the step of establishing artificial hydronephrosis was avoided, the anesthesia time of the operation was significantly shortened, and this can reduce the risk of postoperative pulmonary infection and the damage stimulation of the operation, which could speed up the postoperative recovery of the patient and reduce medical expenses.

This study also has some limitations. The number of cases selected in this study is small, and a large amount of clinical data is needed to verify its effectiveness. This study is a retrospective study and there is a bias in the selection of cases. Further prospective studies are needed to confirm its effectiveness and safety.

5. Conclusion

In conclusion, under the premise of preoperative evaluation and aggressive treatment of the primary disease, ultrasound-guided PCNL without an indwelling ureteral catheter is safe and feasible for older patients with upper urinary calculi, and it has the advantages of short operative time, less intraoperative bleeding, short postoperative hospitalization time, and low medical expenses. In addition, it can reduce the risk of postoperative SIRS.

Author contributions

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Funding acquisition: Xiande Cao.

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