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ORIGINAL ARTICLE

Retrospective Cohort Study

Perioperative and long-term results of ultrasonography-guided single- and multiple-tract percutaneous nephrolithotomy for staghorn calculi

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Abstract

BACKGROUND

It is possible that this condition will lead to urosepsis and progressive deterioration of renal function in the absence of surgical intervention. Several recent clinical studies have shown that multi-tract percutaneous nephrolithotomy (M-PCNL) has a similar stone free rate (SFR) as standard percutaneous nephrolithotomy (S-PCNL). As a result, M-PCNL was also recommended as a treatment option for staghorn calculi.

AIM

To examine the perioperative and long-term results of ultrasonography-guided single- and M-PCNL.

METHODS

This was a retrospective cohort study. Between March 2021 and January 2022, the urology department of our hospital selected patients for the treatment of staghorn calculi using percutaneous nephrolithotomy. The primary outcomes were com-

plication rate and SFR, and the characteristics of patients, operative parameters, laboratory measurements were also collected.

RESULTS

In total, 345 patients were enrolled in the study (186 in the S-PCNL group and 159 in the M-PCNL group). The SFR in the M-PCNL group was significantly higher than that in the S-PCNL group (P = 0.033). Moreover, the incidence rates of hydrothorax (P = 0.03) and postoperative infection (P = 0.012) were higher in the M-PCNL group than in the S-PCNL group. Logistic regression analysis demonstrated that post-operative white blood cell count (OR = 2.57, 95%CI: 1.90-3.47, P < 0.001) and stone size (OR = 1.59, 95%CI: 1.27-2.00, P < 0.001) were associated with a higher overall complication rate in the S-PCNL group. Body mass index (OR = 1.22, 95%CI: 1.06-1.40, P = 0.004) and stone size (OR = 1.70, 95%CI: 1.35-2.15, P < 0.001) were associated with increased overall complications in the M-PCNL group.

CONCLUSION

Multiple access tracts can facilitate higher SFR while slightly increasing the incidence of acceptable complications.

Key Words: Single-tract percutaneous nephrolithotomy; Multiple-tract percutaneous nephrolithotomy; Staghorn calculi; Ultrasonography

Core Tip: It is estimated that 1% to 15% of the population will suffer from kidney stones during their lifetime. Incidences of urinary tract stones are on the rise. The number of Americans with renal stone disease reached 10.6% among men and 7.1% among women in 2012 according to the National Health and Nutrition Examination Survey. In a retrospective study, we examined the perioperative and long-term results of ultrasonography-guided single-tract percutaneous nephrolithotomy (PCNL) and multiple-tract PCNL. Between March 2021 and January 2022, the urology department of our hospital selected patients for the treatment of staghorn calculi by using PCNL. Multiple-access tracts can facilitate higher stone free rate while increasing the incidence of acceptable complications slightly.

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INTRODUCTION

It is estimated that 1% to 15% of the population will suffer from kidney stones during their lifetime[1]. Incidences of urinary tract stones are on the rise. The number of Americans with renal stone disease reached 10.6% among men and 7.1% among women in 2012 according to the National Health and Nutrition Examination Survey[2]. The term "staghorn calculus" refers to a large and branching stone that occupies all or part of the renal pelvis and extends into at least one of the renal calves[3]. It is possible that this condition will lead to urosepsis and progressive deterioration of renal function in the absence of surgical intervention[4]. For staghorn calculi, percutaneous nephrolithotomy (PCNL) is recommended as the first-line therapy[5]. It should be noted, however, that some PCNL-related complications, including fatal urosepsis and severe hemorrhage, continue to occur among patients.

In managing complex renal stones, laparoscopic surgery has gained acceptance as an alternative, minimally invasive technique. According to the American Urological Association (AUA) guidelines, PCNL is the most effective treatment option for staghorn calculi[6]. It has been reported that with PCNL monotherapy, staghorn calculi have a stone-free rate (SFR) of 56%[7]. For patients with staghorn calculi, multiple tracts or sessions of PCNL were required to achieve a high SFR, while tract-related complications increased[8]. Furthermore, several recent clinical studies have shown that multi-tract PCNL (M-PCNL) has a similar SFR as standard PCNL (S-PCNL). As a result, M-PCNL was also recommended as a treatment option for staghorn calculi[9,10].

In this study, we aimed to analyze the perioperative and long-term results of ultrasonography-guided S-PCNL and M-PCNL in the treatment of staghorn calculi.

MATERIALS AND METHODS

Study design and participants

This retrospective study compared the effects of ultrasonography-guided S-PCNL and M-PCNL on patients with staghorn calculi. We conducted the study between March 2021 and January 2022 at our hospital's urology department, following approval by our Certified Research Review Board. This study was conducted in accordance with the Helsinki Declaration. All patients provided their informed consent.

The eligibility criteria were as follows: Age 18 through 80 years and the presence of staghorn calculi greater than 20 mm requiring PCNL. Those who were pregnant or may have become pregnant, those with active pyelonephritis, those who were receiving antiplatelet/coagulant therapy 1 wk prior to surgery, those for whom general or lumbar anesthesia was considered difficult by an anesthesiologist, and those receiving best supportive care for terminal cancer, were excluded from the study.

Demographic information

Physicians recruited and evaluated patients attending our outpatient clinic for study eligibility. We used demographic data which included information about the patients, such as their age, sex, and body mass index (BMI). We collected information related to the disease, such as the position of the renal calculus, the presence of bacteriuria, the presence of hydronephrosis, the side of the renal calculus, and its size.

Outcomes

Stone-free status and overall complication rate were the outcomes of the study. We defined stone-free status as the absence of residual fragments larger than 4 mm on kidney ureter bladder radiography at 1 month following surgery and no residual fragments greater than 2 mm on computed tomography 3 months following surgery[11].

Perioperative parameters and laboratory examination

The operative time, length of hospital stay, pain intensity at 24 h after surgery, bleeding volume, hemoglobin (Hb), Cre, and white blood cell (WBC) levels before and after surgery were collected.

Statistical analysis

Kolmogorov-Smirnov was used to analyze the distribution of the data. Categorical data are presented as numbers and percentages, and the Chi-square test or Fisher's exact test was employed for analysis. Demographic characteristics were calculated using descriptive statistics (mean ± SD). Using logistic regression analysis, factors associated with complications were identified independently. For all analyses, $P < 0.05$ was considered statistically significant. SPSS version 10.0 was used for all analyses.

RESULTS

In total, 345 patients (186 in the S-PCNL group, 36 in the M-PCNL group) were enrolled. The mean age at surgery was 48.91 ± 11.40 years and 49.88 ± 10.75 years in the S-PCNL and M-PCNL groups, respectively. Approximately 40 % patients were male, and the BMI in the S-PCNL and M-PCNL groups were (24.47 ± 2.94) kg/m^2 and (25.79 ± 2.73) kg/m^2, respectively. Approximately one-third of stones were located in the upper calyx and 31.89 % of patients had bacteriuria. The mean stone size was 6.27 and 8.80 in the S-PCNL and M-PCNL groups, respectively. These results are shown in Table 1.

Outcomes

As described in Table 2, the SFR at the 1st, 3rd, and 6th month after surgery were 100 %, 88.17 %, and 67.74 % in the S-PCNL group, and 100 %, 86.79 %, and 77.98 % in the M-PCNL group. The SFR in the M-PCNL group was significantly higher than that in the S-PCNL group ($P = 0.033$). No differences were observed between the groups in pelvicalyceal system perforation or persistent leakage of urine, transfusion needed due to bleeding, urosepsis, fever, renal hemorrhage, and urinary damage. However, the incidence rates of hydrothorax ($P = 0.03$) and postoperative infection ($P = 0.012$) were higher in the M-PCNL group than in the S-PCNL group.

Perioperative parameters and laboratory examination

The mean operation time, length of hospital stay, pain intensity after surgery, bleeding volume, post-operative Hb, and pre-operative Cre were higher in the M-PCNL group than in the S-PCNL group. However, differences in pre-operative Hb levels and WBC levels as well as post-operative Cre and WBC levels of patients receiving S-PCNL and M-PCNL were not found to be statistically significant (Tables 3 and 4).

Factors related to complications in the S-PCNL group

Further evaluation with logistic regression analysis demonstrated that post-operative WBC (OR = 2.57, 95%CI: 1.90-3.47, $P < 0.001$) and stone size (OR = 1.59, 95%CI: 1.27-2.00, $P < 0.001$) were associated with an increased odds ratio for a higher overall complication rate in the S-PCNL group.

Table 1 Preoperative characteristics of study participants, *n* (%)

Parameters	S-PCNL (*n* = 186)	M-PCNL (*n* = 159)	*P* value
Age (yr, mean ± SD)	48.91 ± 11.40	49.88 ± 10.75	0.419
Male	77 (41.39)	69 (43.39)	0.708
BMI (kg/m^2, mean ± SD)	24.47 ± 2.94	25.79 ± 2.73	< 0.001
Position of renal calculus			
Upper calyx	62 (33.33)	58 (36.47)	0.67
Middle calyx	59 (31.72)	53 (33.33)	
Inferior calyx	64 (34.40)	48 (30.18)	
Bacteriuria	59 (31.89)	84 (52.83)	< 0.001
Hydronephrosis			
G 0-I	11 (5.94)	16 (10.06)	0.15
G II-III	2 (1.08)	4 (2.51)	0.30
Side of renal calculus (Left)	82 (44.32)	64 (40.25)	0.47
Stone size (cm^2, mean ± SD)	6.27 ± 2.57	8.80 ± 2.09	< 0.001

S-PNCL: Standard percutaneous nephrolithotomy; M-PNCL: Multi-tract percutaneous nephrolithotomy; BMI: Body mass index.

Table 2 Primary and secondary outcomes, *n* (%)

Parameters	S-PCNL (*n* = 186)	M-PCNL (*n* = 159)	*P* value
The stone free rate (SFR)			
1 month (yes)	186 (100)	159 (100)	-
3 months (yes)	164 (88.17)	138 (86.79)	0.699
6 months (yes)	126 (67.74)	124 (77.98)	0.033
Complication			
Pelvicalyceal system perforation or persistent leakage of urine	10 (5.37)	13 (8.17)	0.242
Transfusion needed because of bleeding	7 (3.76)	11 (6.91)	0.189
Hydrothorax	4 (2.15)	11 (6.91)	0.030
Urosepsis	4 (2.15)	5 (3.14)	0.563
Fever	26 (14.05)	29 (18.23)	0.281
Renal hemorrhage	5 (2.70)	4 (3.77)	0.920
Urinary damage	8 (4.32)	7 (6.28)	0.963
Postoperative infection	3 (1.62)	11 (3.77)	0.012

S-PNCL: Standard percutaneous nephrolithotomy; M-PNCL: Multi-tract percutaneous nephrolithotomy.

Factors related to complications in the M-PCNL group

Logistic regression analysis revealed that BMI levels (OR = 1.22, 95%CI: 1.06-1.40, P = 0.004) and stone size (OR = 1.70, 95%CI: 1.35-2.15, P < 0.001] were associated with increased overall complications in the M-PCNL group. The difference was statistically significant.

DISCUSSION

In this study, a higher BMI level, pre-operative Cre, incidence rate of bacteriuria, hydrothorax, postoperative infection, larger stone size, longer operative time, longer hospital stay, greater pain intensity, and greater bleeding volume, as well as lower pre-operative Hb levels and SFR were observed in the M-PCNL group. Multivariate analysis revealed that post-

Table 3 Perioperative parameters comparison between ultrasound-guided and RAF-guided renal aces (mean ± SD)

	S-PCNL (*n* = 186)	M-PCNL (*n* = 159)	*P* value
Operative time (min)	125.26 ± 46.45	153.26 ± 31.26	< 0.001
Hospital stay (d)	4.06 ± 1.85	5.94 ± 2.05	< 0.001
Pain intensity at 24 h after surgery	2.16 ± 1.26	3.67 ± 1.64	< 0.001
Bleeding volume (mL)	26.43 ± 3.85	52.49 ± 4.68	< 0.001

S-PNCL: Standard percutaneous nephrolithotomy; M-PNCL: Multi-tract percutaneous nephrolithotomy.

Table 4 Comparison of effect of percutaneous nephrolithotomy on renal function (mean ± SD)

Parameters	S-PCNL (*n* = 186)	M-PCNL (*n* = 159)	*P* value
Hb (× 10^2 g/L)			
Pre-operation	1.41 ± 0.25	1.41 ± 0.18	0.83
Post-operation	1.23 ± 0.12	1.09 ± 0.17	< 0.001
Cre (μmol/L)			
Pre-operation	83.18 ± 6.92	86.20 ± 5.60	< 0.001
Post-operation	81.46 ± 7.29	82.49 ± 6.78	0.176
WBC (× 10^9/L)			
Pre-operation	6.60 ± 2.32	5.76 ± 2.11	0.069
Post-operation	7.52 ± 2.55	7.24 ± 2.54	0.306

S-PNCL: Standard percutaneous nephrolithotomy; M-PNCL: Multi-tract percutaneous nephrolithotomy; WBC: White blood cells.

operative WBC levels and stone size were associated with increased overall complications in the S-PCNL group, and BMI levels and stone size were associated with increased overall complications in the M-PCNL group.

There is a direct correlation between renal access during PCNL and surgical outcomes, including complications[12]. There are many benefits associated with PCNL according to the guidelines published by the AUA. Using PCNL, kidney stones can almost always be removed, as small fragments can be identified and removed directly from the collecting system. Moreover, due to the tract's ability to remain open indefinitely, inspections can be repeated at any time, and it is usually obvious whether a procedure is successful[13]. Consequently, the AUA recommends PCNL for the majority of patients with large-volume renal staghorn calculi[14]. Multiple renal accesses have been associated with a decrease in renal function at postoperative follow-up in PCNL studies[15]. Additionally, fewer needle punctures may help preserve renal function following surgery[16].

There have been various publications that report SFR, incidences of post-surgery complications, and the need for an auxiliary procedure as 70%, 10 %, and 20%, respectively[17-19]. Patients and theater staff must be prepared to deal with multiple tracts when treating staghorn calculi. A significant increase in the risks of complications, including organ injury and bleeding, including duration of fluoroscopy and operation as well as the expertise needed for certain surgeries, was associated with percutaneous surgery[18]. A study was conducted to investigate the effects of the number of access points. There was no significant difference between the multiple access group and the single access group in terms of the preoperative clinic parameters except for BMI levels and the incidence of bacteriuria. The number of access points did not significantly correlate with other factors such as age, sex, location of renal calculus, hydronephrosis, or side of renal calculus. In our study, the mean ages of the patients in the S-PCNL and M-PCNL groups were 48.91 ± 11.40 years and 49.88 ± 10.75 years, respectively. These results are similar to those of the previous studies conducted by Fayad *et al*[18], Gorbachinsky *et al*[14], and Moskovitz *et al*[20]. Moreover, previous research revealed that the incidence of renal stones in males (1.5:1) is similar to that reported by Fayad *et al*[18] and is in accordance to the reportedly high incidence of renal calculi in males[21,22]. In this study, 77 patients (41.39%) were male in the S-PCNL group, while 69 patients (43.9%) were male in the M-PCNL group.

There has been a range of 1.5-3.2% blood transfusion rates reported in previous studies of PCNL[23,24]. As a result of the larger percutaneous tract and the need to manipulate the renal parenchyma in PCNL, the incidence of hemorrhage requiring blood transfusion has been found to increase from 20% to 30%[25]. Moreover, blood transfusion requirements during PCNL were independently affected by multiple tract punctures[26]. In our study, the bleeding volume was higher in the M-PCNL group than in the S-PCNL group. Additionally, the incidence rates of hydrothorax and postoperative infection were higher in the M-PCNL group. Previous studies have confirmed that M-PCNL is more likely to cause postoperative blood transfusions, postoperative infections, and pleural damage[27]. The changes in serum Cre levels of

patients treated with M-PCNL were not significantly different from those of patients treated with S-PCNL[27]. However, our study found that Hb levels at post-operation were lower and Cre levels were higher in the M-PCNL group at pre-operation, which may relate to the bleeding volume and renal functions.

Our study also showed that higher post-operative WBC levels and larger stone size were related to the overall complications in the S-PCNL group, and BMI levels and stone size were related to the overall complications in the M-PCNL group. An increased risk of complications was independently associated with increasing age, a large lithiasic burden, and stones in the lower calyx. Compared with the younger population, older patients appeared to be more vulnerable. The aging urinary tract system as well as an increased volume of the prostate in male patients may contribute to the development of lower urinary tract symptomatology, infections, and fever in older patients following surgery[28].

This study had several limitations. Single-pass PCNL has a faster recovery time and less pain than traditional surgical methods. However, like other surgeries, it carries certain risks and should therefore be performed by experienced physicians. it was found that cases with larger percutaneous tract sizes were associated with a higher risk of complication, and this factor will be considered in future studies. A multicenter study with a larger volume may be statistically more effective in obtaining more sophisticated evidence. In addition, a cost estimation should be provided for comparing these two methods in daily practice. Finally, the heterogeneity of the surgical methods, such as the types of lead surgeons at the PCNL side and the patients' positionings, were potential confounding factors.

CONCLUSION

Complications acceptable to the patient have increased slightly, and multiple access tracts resulting in a higher SFR can be used for PCNL. Both single- and multiple-access PCNL have similar effects on renal function, which are temporary.

ARTICLE HIGHLIGHTS

Research methods

In order to investigate the perioperative and long-term implications of ultrasound-guided percutaneous nephrolithotomy (PCNL), this study will examine the outcomes associated with both single and multi-channel surgical techniques.

Research objectives

To compare the perioperative and long-term outcomes of ultrasonography-guided single- and multiple-tract PCNL (M-PCNL) for the treatment of staghorn calculi.

Research motivation

Based on our findings, we propose S-PCNL as a viable and efficacious therapeutic approach for individuals diagnosed with staghorn calculi.

Research background

Single-pass PCNL is a common surgical procedure and is mainly used for the treatment of kidney stones. The procedure involves a small incision in the skin of the kidney area and then inserting the renoscope into the inside of the kidney. Nephoscopy is localized and broken into small pieces, and finally excreted from the body through urine.

Research conclusions

Single-pass PCNL exhibits superior outcomes in terms of expedited recovery time and diminished pain compared to conventional surgical approaches.

Research results

Our study revealed that ultrasound-guided PCNL offers several notable benefits, including reduced trauma, expedited recovery, and a high rate of stone clearance. Additionally, this procedure effectively mitigates the occurrence of complications.

Research perspectives

M-PCNL is typically reserved for patients with complex kidney stones that cannot be removed through less invasive methods.

FOOTNOTES

Co-first authors: Rui-Xiang Cheng and Ni Dai.

Author contributions: Cheng RX and Dai N designed and performed the experiments, and writing the manuscript; Wang YM, Qi P provided support for data analysis, resource, and discussion; Chen F provided the supervision, design and peer review process; all the

authors have seen and approved the manuscript.

Institutional review board statement: This study protocol was approved by Hubei Provincial Hospital of Integrated Traditional Chinese and Western Medicine, and all the families have voluntarily participated in the study and have signed informed consent forms.

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors declared no conflict of interest existing in this paper.

Data sharing statement: Data generated from this investigation are available upon reasonable quest from the corresponding author.

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REFERENCES

1 **Xu G**, Wen J, Li Z, Zhang Z, Gong X, Chen J, Du C. A comparative study to analyze the efficacy and safety of flexible ureteroscopy combined with holmium laser lithotripsy for residual calculi after percutaneous nephrolithotripsy. *Int J Clin Exp Med* 2015; **8**: 4501-4507 [PMID: 26064375]

2 **Stamatelou KK**, Francis ME, Jones CA, Nyberg LM, Curhan GC. Time trends in reported prevalence of kidney stones in the United States: 1976-1994. *Kidney Int* 2003; **63**: 1817-1823 [PMID: 12675858 DOI: 10.1046/j.1523-1755.2003.00917.x]

3 **Sharbaugh A**, Morgan Nikonow T, Kunkel G, Semins MJ. Contemporary best practice in the management of staghorn calculi. *Ther Adv Urol* 2019; **11**: 1756287219847099 [PMID: 35173810 DOI: 10.1177/1756287219847099]

4 **Morgan TN**, Shahait M, Maganty A, Ost M, Jackman S, Averch T, Semins MJ. Conservative Management of Staghorn Calculi: When Is It Safe? *J Endourol* 2018; **32**: 541-545 [PMID: 29495888 DOI: 10.1089/end.2018.0002]

5 **Torricelli FCM**, Monga M. Staghorn renal stones: what the urologist needs to know. *Int Braz J Urol* 2020; **46**: 927-933 [PMID: 32213203 DOI: 10.1590/S1677-5538.IBJU.2020.99.07]

6 **Preminger GM**, Assimos DG, Lingeman JE, Nakada SY, Pearle MS, Wolf JS Jr; AUA Nephrolithiasis Guideline Panel). Chapter 1: AUA guideline on management of staghorn calculi: diagnosis and treatment recommendations. *J Urol* 2005; **173**: 1991-2000 [PMID: 15879803 DOI: 10.1097/01.ju.0000161171.67806.2a]

7 **el-Nahas AR**, Eraky I, Shokeir AA, Shoma AM, el-Assmy AM, el-Tabey NA, Soliman S, Elshal AM, el-Kappany HA, el-Kenawy MR. Factors affecting stone-free rate and complications of percutaneous nephrolithotomy for treatment of staghorn stone. *Urology* 2012; **79**: 1236-1241 [PMID: 22465085 DOI: 10.1016/j.urology.2012.01.026]

8 **Schuster TG**, Hollenbeck BK, Faerber GJ, Wolf JS Jr. Ureteroscopic treatment of lower pole calculi: comparison of lithotripsy in situ and after displacement. *J Urol* 2002; **168**: 43-45 [PMID: 12050489]

9 **Wen J**, Xu G, Du C, Wang B. Minimally invasive percutaneous nephrolithotomy versus endoscopic combined intrarenal surgery with flexible ureteroscope for partial staghorn calculi: A randomised controlled trial. *Int J Surg* 2016; **28**: 22-27 [PMID: 26898135 DOI: 10.1016/j.ijsu.2016.02.056]

10 **Taguchi K**, Hamamoto S, Okada A, Sugino T, Unno R, Kato T, Fukuta H, Ando R, Kawai N, Tan YK, Yasui T. A Randomized, Single-Blind Clinical Trial Comparing Robotic-Assisted Fluoroscopic-Guided with Ultrasound-Guided Renal Access for Percutaneous Nephrolithotomy. *J Urol* 2022; **208**: 684-694 [PMID: 35549460 DOI: 10.1097/JU.0000000000002749]

11 **Mishra S**, Sabnis RB, Desai MR. Percutaneous nephrolithotomy monotherapy for staghorn: paradigm shift for 'staghorn morphometry' based clinical classification. *Curr Opin Urol* 2012; **22**: 148-153 [PMID: 22223067 DOI: 10.1097/MOU.0b013e32834fc306]

12 **Ventimiglia E**, Quadrini F, Pauchard F, Villa L, Candela L, Proietti S, Giusti G, Pietropaolo A, Somani BK, Goumas IK, Salonia A, Doizi S, Traxer O. Pattern of key opinion leaders talks at major international urological meetings reflects the main differences in flexible ureteroscopy and PCNL diffusion. *World J Urol* 2023; **41**: 229-233 [PMID: 36445371 DOI: 10.1007/s00345-022-04209-7]

13 **Desai M**, Sun Y, Buchholz N, Fuller A, Matsuda T, Matlaga B, Miller N, Bolton D, Alomar M, Ganpule A. Treatment selection for urolithiasis: percutaneous nephrolithomy, ureteroscopy, shock wave lithotripsy, and active monitoring. *World J Urol* 2017; **35**: 1395-1399 [PMID: 28303335 DOI: 10.1007/s00345-017-2030-8]

14 **Gorbachinsky I**, Wood K, Colaco M, Hemal S, Mettu J, Mirzazadeh M, Assimos DG, Gutierrez-Aćeves J. Evaluation of Renal Function after Percutaneous Nephrolithotomy-Does the Number of Percutaneous Access Tracts Matter? *J Urol* 2016; **196**: 131-136 [PMID: 26925873 DOI: 10.1016/j.juro.2016.01.121]

15 **Zeng G**, Cai C, Duan X, Xu X, Mao H, Li X, Nie Y, Xie J, Li J, Lu J, Zou X, Mo J, Li C, Wang W, Yu Y, Fei X, Gu X, Chen J, Kong X, Pang

J, Zhu W, Zhao Z, Wu W, Sun H, Liu Y, la Rosette J. Mini Percutaneous Nephrolithotomy Is a Noninferior Modality to Standard Percutaneous Nephrolithotomy for the Management of 20-40mm Renal Calculi: A Multicenter Randomized Controlled Trial. *Eur Urol* 2021; **79**: 114-121 [PMID: 32994063 DOI: 10.1016/j.eururo.2020.09.026]

16 **Diri A**, Diri B. Management of staghorn renal stones. *Ren Fail* 2018; **40**: 357-362 [PMID: 29658394 DOI: 10.1080/0886022X.2018.1459306]

17 **Lojanapiwat B**. Does previous open nephrolithotomy affect the efficacy and safety of tubeless percutaneous nephrolithotomy? *Urol Int* 2010; **85**: 42-46 [PMID: 20606406 DOI: 10.1159/000318188]

18 **Fayad AS**, Elsheikh MG, Mosharafa A, El-Sergany R, Abdel-Rassoul MA, Elshenofy A, Ghamrawy H, El Bary AA, Fayad T. Effect of multiple access tracts during percutaneous nephrolithotomy on renal function: evaluation of risk factors for renal function deterioration. *J Endourol* 2014; **28**: 775-779 [PMID: 24564455 DOI: 10.1089/end.2013.0771]

19 **Bolat D**, Aydogdu O. Re: Evaluation of Renal Function after Percutaneous Nephrolithotomy-Does the Number of Percutaneous Access Tracts Matter?: I. Gorbachinsky, K. Wood, M. Colaco, S. Hemal, J. Mettu, M. Mirzazadeh, D. G. Assimos and J. Gutierrez-Aćeves J Urol 2016;196:131-136. *J Urol* 2017; **197**: 823-824 [PMID: 28351125 DOI: 10.1016/j.juro.2016.10.064]

20 **Moskovitz B**, Halachmi S, Sopov V, Burbara J, Horev N, Groshar D, Nativ O. Effect of percutaneous nephrolithotripsy on renal function: assessment with quantitative SPECT of (99m)Tc-DMSA renal scintigraphy. *J Endourol* 2006; **20**: 102-106 [PMID: 16509791 DOI: 10.1089/end.2006.20.102]

21 **Ganpule AP**, Naveen Kumar Reddy M, Sudharsan SB, Shah SB, Sabnis RB, Desai MR. Multitract percutaneous nephrolithotomy in staghorn calculus. *Asian J Urol* 2020; **7**: 94-101 [PMID: 32257801 DOI: 10.1016/j.ajur.2019.10.001]

22 **Zhao Z**, Cui Z, Zeng T, Wan SP, Zeng G. Comparison of 1-stage With 2-stage Multiple-tracts Mini-percutaneous Nephrolithotomy for the Treatment of Staghorn Stones: A Matched Cohorts Analysis. *Urology* 2016; **87**: 46-51 [PMID: 26505833 DOI: 10.1016/j.urology.2015.09.006]

23 **Akman T**, Sari E, Binbay M, Yuruk E, Tepeler A, Kaba M, Muslumanoglu AY, Tefekli A. Comparison of outcomes after percutaneous nephrolithotomy of staghorn calculi in those with single and multiple accesses. *J Endourol* 2010; **24**: 955-960 [PMID: 20443700 DOI: 10.1089/end.2009.0456]

24 **Patel U**. Percutaneous nephrostomy insertion: outcome data from a prospective multi-operator study at a UK training centre. *Clin Radiol* 2004; **59**: 253-254 [PMID: 15037137 DOI: 10.1016/j.crad.2003.10.022]

25 **Abu-Ghanem Y**, Forster L, Khetrapal P, Ellis G, Singh P, Srinivasan R, Kucheria R, Goyal A, Allen D, Goode A, Yu D, Ajayi L. Factors Predicting Outcomes of Supine Percutaneous Nephrolithotomy: Large Single-Centre Experience. *J Pers Med* 2022; **12** [PMID: 36556177 DOI: 10.3390/jpm12121956]

26 **Ketsuwan C**, Pimpanit N, Phengsalae Y, Leenanupunth C, Kongchareonsombat W, Sangkum P. Peri-Operative Factors Affecting Blood Transfusion Requirements During PCNL: A Retrospective Non-Randomized Study. *Res Rep Urol* 2020; **12**: 279-285 [PMID: 32802804 DOI: 10.2147/RRU.S261888]

27 **Song R**, Ji C, Cong R, Luan J, Yao L, Song N, Meng X. Is It Safe to Increase the Number of Percutaneous Nephrolithotomy Channels: A Systematic Review and Meta-Analysis. *Arch Esp Urol* 2022; **75**: 819-830 [PMID: 36651092 DOI: 10.56434/j.arch.esp.urol.20227510.120]

28 **Kozyrakis D**, Soukias G, Karagiannis D, Zarkadas A, Perikleous S, Chatzistamou SE, Katsaros I, Skriapas K, Lardas M, Mertziotis N, Kratiras Z. Prognostic factors for the safety and efficacy of retrograde laser lithotripsy: Data from a contemporary series of 155 consecutive patients with single and multiple lithiasis of the urinary tract. *Exp Ther Med* 2022; **23**: 294 [PMID: 35340875 DOI: 10.3892/etm.2022.11221]

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