# Percutaneous nephrolithotomy assisted by LithoClast master in one-phase treatment for staghorn renal stones with refractory infections

**Hai-Xiao Tang** ( tanghaixiao12138@163.com )
Shanghai Jiaotong University School of Medicine Xinhua Hospital https://orcid.org/0000-0003-3761-2847

**Di Wu**
Shanghai Jiao Tong University School of Medicine

**Bo-Wen Shi**
Shanghai Jiao Tong University

**Ze-Hao Dai**
Shanghai Jiao Tong University School of Medicine

**Yun-Teng Huang**
Shanghai Jiao Tong University School of Medicine

**Research article**

**Keywords:** Percutaneous nephrolithotomy, LithoClast, Staghorn renal stones, Refractory infections, Balloon dilatation

**DOI:** https://doi.org/10.21203/rs.3.rs-38642/v1

# Abstract

**Background:** Infectious staghorn renal stones are usually treated with one-phase for percutaneous puncture and drainage, and then two-phase for percutaneous nephrolithotomy (PCNL). The objective of the study was to evaluate the efficacy and safety of PCNL assisted by LithoClast master (the fifth-generation Electro Medical Systems, EMS) in one-phase treatment for staghorn renal stones with refractory infections.

**Methods:** From September 2017 to September 2019, 80 patients with staghorn renal stones who underwent one-phase for PCNL combined with the fifth-generation EMS in our hospital were retrospectively analyzed. According to whether patients with staghorn renal stones were complicated with refractory infections or not before operation, they were divided into A group (48 cases with refractory infections) and B group (32 cases without infections). In A group, refractory infections were properly controlled with sensitive antibiotics before operation. The efficacy and safety of treatment for two groups were compared.

**Results:** Before taking sensitive antibiotics in A group, there was statistical difference in the location of stones between the two groups ($P$<0.05), while there were no statistical significances in other general clinical data between the two groups ($P$>0.05). Although there were statistical differences in the increase rate of white blood cell count, C-reactive protein, procalcitonin on the first day after operation between the two groups ($P$<0.05), there were no statistical differences in operation time, hospitalization time, hemoglobin, stone-free rate, Clavien-Dindo grade I complications, Clavien-Dindo grade II and above complications between the two groups ($P$>0.05).

**Conclusions:** For staghorn renal stones with refractory infections, based on the application of sensitive antibiotics before operation to properly control refractory infections, PCNL assisted by the fifth-generation EMS in one-phase can efficiently remove staghorn renal stones, without increasing the risk of postoperative complications. In the medical center with mature technical conditions and rich experience, staghorn renal stones with refractory infections can be selected carefully to carry out one-phase operation.


# Background

Staghorn renal stones refer to large branching stones that fill the renal pelvis and part or even all of the renal calices [1]. Depending on the occupancy level of the collecting system, staghorn renal stones can be partial or complete [1, 2]. Percutaneous nephrolithotomy (PCNL) is recommended as the first-line treatment for staghorn renal stones due to its low morbidity and superior efficacy [3, 4]. Staghorn renal stones are mostly mixtures, which are composed of magnesium ammonium phosphate and/or calcium carbonate apatite and are closely associated with urinary tract infection (UTI) [1, 2]. Generally, infectious staghorn renal stones are treated with one-phase for percutaneous puncture and drainage, and then two-phase for PCNL [5].

For the fragmentation of renal stones, all sorts of lithotriptors can be used, including electrohydraulic, ultrasonic, pneumatic and laser lithotriptors [6–8]. Reportedly, PCNL assisted by LithoClast Master (the third-generation Electro Medical System, EMS) can achieve a high stone-free rate (SFR) with acceptable morbidity for one-session treatment of staghorn renal stones [9]. At present, the fifth-generation EMS is the latest generation of minimally invasive EMS lithotripsy. Therefore, we conducted this study to evaluate the efficacy and safety of one-phase treatment for staghorn renal stones with refractory infections undergoing PCNL assisted by the fifth-generation EMS. The study may provide a novel perspective for the treatment of staghorn renal stones with refractory infections.

## Patients And Methods

# Patients

From September 2017 to September 2019, 80 patients diagnosed with staghorn renal stones by ultrasound (US), plain film of kidney-ureter-bladder (KUB) or computed tomography (CT) at the Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine (Shanghai, China) were retrospectively analyzed. The Ethics Committee of Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine has approved the study (reference number: XHEC-D-2020-101), and verbal consents were obtained from all the participants because all the information was required from historic electronic records. The inclusion criteria for this study were: i) Age, ≥12 and ≤ 75 years; ii) staghorn renal stones with refractory infections, or without infections; iii) PCNL assisted by the fifth-generation EMS lithotripsy; and iv) one-phase treatment. The exclusion criteria were: i) Patients with other complex renal stones, ureteral stones, bladder stones, renal tumor, renal tuberculosis, acute and chronic nephritis, or nephrotic syndrome; ii) patients with severe lung, heart, urinary system abnormalities, or blood system diseases; and iii) patients with incomplete clinical data, or poor compliance, or those who interrupted treatment.

Patients with staghorn renal stones were divided into A group (n = 48, with refractory infections) and B group (n = 32, without infections) according to whether they were complicated with refractory infections. In A group, there were 23 males (47.92%) and 25 females (52.08%), and an average age of 53.54 ± 9.50 years (age range, 31–71 years). The average value of body mass index (BMI) was 24.16 ± 3.15 kg/$m^2$ (BMI range, 18.08–32.05 kg/$m^2$). There were 11 patients (22.92%) with hypertension and six patients (12.50%) with diabetes. The surface area (SA) of stones ranged from 91.61 to 4541.78 $mm^2$, with an average of 733.67 ± 760.25 $mm^2$. There were 28 stones (58.33%) on the left side and 20 stones (41.67%) on the right side. The CT value of stones ranged from 336.90 to 1372.30 Hu, and an average of 957.87 ± 269.00 Hu. Before operation, there were 47 cases (97.92%) with white blood cell (WBC) count (≤ $10 \times 10^9$/L), and only 1 case (2.08%) with WBC count (≥$10 \times 10^9$/L). There were ten patients (20.83%) with preoperative C-reactive protein (CRP;≥8 mg/L). The range of preoperative hemoglobin (Hb) was 85.00-177.00 g/L, with an average value of 132.42 ± 18.70 g/L. Moreover, there were 25 patients (52.08%) with hydronephrosis and seven patients (14.58%) with renal insufficiency.

In B group, there were 22 males (68.75%) and ten females (31.25%), with an average age of 54.19 ± 14.61 years (age range, 14–73 years). The range of BMI was 16.98–31.28 kg/$m^2$, and an average of 23.58 ± 3.15 kg/$m^2$. Among them, there were 12 cases (37.50%) of hypertension and 3 cases (9.38%) of diabetes. The patients had staghorn renal stones of 134.77-2718.15 $mm^2$ in SA and an average of 613.74 ± 493.79 $mm^2$, with 11 stones (34.38%) on the left side, and 21 stones (65.63%) on the right side. The CT value of stones ranged from 374.10 to 1416.40 Hu, with an average of 883.77 ± 286.98 Hu. Before operation, there were 31 patients (96.88%) with WBC count ($\leq 10 \times 10^9$/L), and only 1 case (3.13%) with WBC count ($>10 \times 10^9$/L). There was one patient (3.13%) with preoperative CRP (≥ 8 mg/L). The preoperative Hb ranged from 108.00 to 166.00 g/L, with an average of 136.56 ± 17.51 g/L. In addition, there were 16 cases (50.00%) of hydronephrosis and 6 cases (18.75%) of renal insufficiency. Before operation, there was statistical significance in the location of stones between the two groups ($P$ = 0.036), while there were no statistical significances in other general clinical data between the two groups ($P>0.05$), as shown in Table 1.

Table 1
Comparison of preoperative general clinical data between A group and B group

| Variables | A group (n = 48) | B group (n = 32) | *P* value |
|---|---|---|---|
| Gender | | | |
| Male | 23 (47.92%) | 22 (68.75%) | 0.066 |
| Female | 25 (52.08%) | 10 (31.25%) | |
| Age, years | 53.54 ± 9.50 | 54.19 ± 14.61 | 0.811 |
| BMI, $kg/m^2$ | 24.16 ± 3.15 | 23.58 ± 3.15 | 0.423 |
| Hypertension | 11 (22.92%) | 12 (37.50%) | 0.158 |
| Diabetes | 6 (12.50%) | 3 (9.38%) | 0.942 |
| Location of stones | | | |
| Left | 28 (58.33%) | 11 (34.38%) | 0.036 |
| Right | 20 (41.67%) | 21 (65.62%) | |
| SA of stones, $mm^2$ | 733.67 ± 760.25 | 613.74 ± 493.79 | 0.433 |
| CT value of stones, Hu | 957.87 ± 269.00 | 883.77 ± 286.98 | 0.243 |
| WBC count ($\geq 10 \times 10^9/L$) | 1 (2.08%) | 1 (3.13%) | 1.000 |
| CRP (≥ 8 mg/L) | 10 (20.83%) | 1 (3.13%) | 0.055 |
| Hb, g/L | 132.42 ± 18.70 | 136.56 ± 17.51 | 0.322 |
| Hydronephrosis | 25 (52.08%) | 16 (50.00%) | 0.855 |
| Renal insufficiency | 7 (14.58%) | 6 (18.75%) | 0.621 |

BMI, Body mass index; SA, Surface area; CT, Computed tomography; WBC, White blood cell; CRP, C-reactive protein; Hb, Hemoglobin.

# Surgical procedures

After general anesthesia, patients with staghorn renal stones were in the position of lithotomy. The Wolf F8/9.8 rigid ureteroscope (Richard Wolf GmbH, Knittlingen, Germany) was retrogradely inserted into the F5 ureteral catheter (Shanghai Shangyi Kangge Medical Equipment Co., Ltd, Shanghai, China) to renal pelvis or upper ureter of the affected side, and was fixed together with the F18 Bard urinary catheter. Subsequently, change the patients to a prone position and raise the patients' waist. The percutaneous puncture sites of patients with staghorn renal stones were guided by US in vitro. The method of puncture adopted a combination of US in-plane and out-of-plane (as well as the head and sides of the US probe).

After the puncture needle entered the renal calices on the dorsal side, a black loach guide wire (Cook Medical, Inc., Bloomington, IN, USA) was inserted. F8 fascial dilator was placed along the black loach guide wire and pre-expanded, followed by the balloon dilator. Infuse normal saline into a pressure pump. When the pressure reached 25 Kpa, the balloon was expanded to F24, and the F24 sheath was pushed along the balloon dilator (C. R. Bard,  Inc., Covington, Georgia, USA) to establish the F24 skin renal channel. After establishing the F24 skin renal channel, the operator placed a nephroscope to observe the condition of each patient's renal calves and staghorn renal stones, and then crushed the stones with the fifth-generation EMS Swiss LthoClast®LCM21. For staghorn renal stones with refractory infections, the surgeon adopted the negative pressure suction of the fifth-generation EMS lithotripsy to clear the purulent fluid in the affected kidney. Under the condition of continuous low pressure, stones in the renal pelvis and the renal calices were quickly crushed by US lithotripsy and sucked out by negative pressure suction. After the stones were cleared, the F6 D-J tube (Cook Medical, Inc., Limerick, Ireland) was inserted antegrade through the nephroscope, and the F22 silicone drainage tube was inserted. If there was no active bleeding, the nephrostomy tube was opened; If there was active bleeding, the nephrostomy tube was clamped for 1 to 3 hours.

After PCNL, the patients took antibiotics for prophylactic anti-infection treatment. KUB was reexamined 2-3 days after operation in order to understand the position of F6 D-J tube and the residual situation of stones. If the stones were not removed during operation, extracorporeal shock wave lithotripsy (ESWL), flexible ureteroscopy lithotripsy (FURL) or PCNL of the two-phase were performed; If the stones were removed during operation, the urinary catheter was removed on the 5th day after operation, and the F22 nephrostomy tube was clamped for 1 day. If there was no swelling or fever, the nephrostomy tube was removed on the 6th day after operation. After 4-6 weeks, KUB or CT were reexamined in the outpatient department to understand the stones discharge and remove the F6 D-J tube.

# Observation indexes and detection methods

The differences on gender, age, BMI, hypertension, diabetes, location of stones, SA of stones, CT value of stones, preoperative WBC count, preoperative CRP, preoperative Hb, hydronephrosis, renal dysfunction, operation time, hospitalization time, WBC count on the first day after operation, CRP on the first day after operation, procalcitonin (PCT) on the first day after operation, postoperative Hb, SFR, complications including fever (≥38.5 °C), using analgesics after operation, UTI, systemic inflammatory response syndrome (SIRS), blood transfusion and collecting system perforation between the two groups were compared. At present, there is still a lack of unified standards for refractory infection. Therefore, we defined refractory infection in this study as patients with staghorn renal stones before operation who still had UTI, or urine culture was still positive after treatment with sensitive antibiotics, or purulent urine or infectious flocculent was still observed in the renal pelvis and renal calices during operation. Operation time was from the establishment of the channel to the placement of nephrostomy tube. Hospitalization time was from the first day after operation to the day of discharge. SFR referred to the fragments of retained stone with a size of 0.40 cm or no retained stone found and free from any clinical symptoms

under CT, KUB or US examination within 3 months after operation. Modified Clavien-Dindo grading system was used to grade postoperative complications.

# Statistical analysis

The statistical analysis of all the clinical data was performed with SPSS 25.0 software (IBM SPSS, Armonk, NY, USA). Measurement data were expressed as the mean ± standard deviation, and comparison between the groups was analyzed using the t-test. Qualitative data were expressed as number (percentage), and comparison between the groups was made applying the $\chi^2$ test. $P$ 0.05 was deemed to be statistically significant.

## Results

# Comparison of operation time and hospitalization time

In A group and B group, the average operation time was 76.85 ± 9.06 min and 80.56 ± 8.44 min, respectively. There was no statistical significance in the operation time between the two groups ($P$ = 0.069). In A group and B group, the average hospitalization time was 7.44 ± 2.02 days and 7.50 ± 2.17 days, respectively. There was no statistical significance in the hospitalization time between the two groups ($P$ = 0.896), as shown in Table 2.

Table 2
Comparison of postoperative clinical data between A group and B group

| Variables | A group (n = 48) | B group (n = 32) | *P* value |
|---|---|---|---|
| Operation time, mins | 76.85 ± 9.06 | 80.56 ± 8.44 | 0.069 |
| Hospitalization time, days | 7.44 ± 2.02 | 7.50 ± 2.17 | 0.896 |
| WBC count* (>10 × $10^9$/L) | 18 (37.50%) | 4 (12.50%) | 0.014 |
| CRP* (≥ 8 mg/L) | 14 (29.17%) | 3 (9.38%) | 0.034 |
| PCT* (≥ 0.05 ng/mL) | 17 (35.42%) | 4 (12.50%) | 0.022 |
| Hb, g/L | 129.27 ± 15.47 | 129.34 ± 18.28 | 0.985 |
| SFR | 39 (81.25%) | 27 (84.38%) | 0.719 |
| Complications | | | |
| Grade I | 20 (41.67%) | 12 (37.50%) | 0.709 |
| Fever (≥ 38.5 °C) | 5 (10.42%) | 3 (9.38%) | |
| Using analgesics | 7 (14.58%) | 4 (12.50%) | |
| UTI | 8 (16.67%) | 5 (15.63%) | |
| Grade II and above | 3 (6.25%) | 0 (0%) | 0.400 |
| SIRS | 3 (6.25%) | 0 (0%) | |
| Blood transfusion | 0 (0%) | 0 (0%) | |
| Collecting system perforation | 0 (0%) | 0 (0%) | |
| *Data on the first day after operation. | | | |
| WBC, White blood cell; CRP, C-reactive protein; PCT, Procalcitonin; Hb, Hemoglobin; SFR, Stone-free rate; UTI, Urinary tract infection; SIRS, Systemic inflammatory response syndrome. | | | |

# Comparison of WBC count, CRP and PCT on the first day after operation

In A group and B group, there were 18 cases (37.50%) and 4 cases (12.50%) of WBC count (>10 ×$10^9$/L), 14 cases (29.17%) and 3 cases (9.38%) of CRP (≥8 mg/L), 17 cases (35.42%) and 4 cases (12.50%) of PCT (≥0.05 ng/mL), respectively. Differences on the increase rate of WBC count, CRP and PCT on the first day after operation between A group and B group were statistically significant (*P*=0.014, *P*=0.034 and *P*=0.022, respectively), as shown in Table 2.

# Comparison of postoperative Hb and SFR

In A group and B group, the average Hb after operation was 129.27 ± 15.47 g/L and 129.34 ± 18.28 g/L, respectively. There was no statistical significance in the average Hb after operation between the two groups (*P*=0.985). SFR of A group and B group was 81.25% and 84.38% respectively, and there was no statistically significant in SFR between the two groups (*P*=0.719), as shown in Table 2.

# Comparison of postoperative complications

In A group and B group, there were 5 cases and 3 cases of postoperative fever (≥38.5 °C), 7 cases and 4 cases of using analgesics, 8 cases and 5 cases of UTI, respectively. Difference on Clavien-Dindo grade I complications (41.67% and 37.50%, respectively) after operation between A group and B group was not statistically significant (*P*=0.709). In A group and B group, there were 3 cases and 0 case of postoperative SIRS, respectively. There was no postoperative blood transfusion or collecting system perforation in both groups. Difference on Clavien-Dindo grade II and above complications (6.25% and 0.00%, respectively) after operation between A group and B group was not statistically significant (*P*=0.400), as shown in Table 2.

# Discussion

For patients with staghorn renal stones, PCNL is an established treatment regimen. So far, PCNL has made many innovations in equipment and technology, such as the application of balloon dilation and the fifth-generation EMS. In this study, we attempted to use this technique in a one-phase treatment of staghorn renal stones with refractory infections. To our knowledge, the study is the first report on the one-phase treatment of staghorn renal stones with refractory infections by PCNL assisted by the fifth-generation EMS lithotripsy.

The creation of a nephrostomy channel is the key procedure for a successful PCNL [10, 11]. The steps of channel establishment are mainly divided into puncture and dilation, which requires the surgeon to accurately puncture and rapidly dilate [12, 13]. Generally, puncture is guided in vitro by X-ray or US [12, 14]. Since US is not only free from contrast agents, but also beneficial for identification of important blood vessels including renal artery, vein and arcuate arteries, we adopted US-guided puncture. In our study, 80 patients with staghorn renal stones underwent US-guided percutaneous puncture technique, and all patients were successful in a single puncture.

The traditional method of channel dilatation involves the application of fascial dilators, metal dilators and balloon dilators [10, 15–17]. Among them, balloon dilators are characterized by non-compliance and can be a transverse and homogeneous dilation [18]. This expansion can produce a kind of radial blunt lateral pressure, which evenly changes the diameter and shape of the balloon, thereby reducing the possibility of tearing and bleeding of tiny blood vessels in the kidney [18, 19]. Balloon dilators can expand to F24 at a single time and effectively expand the whole channel, rather than expanding a point or a segment of the channel. The force generated between the balloon dilators and the tissue surrounding the

channel will not cause the dilators to move easily, avoiding the risk of channel loss, too long channel or too short channel, and thus greatly shortening the operation time [18]. Moreover, balloon dilators can reduce the risk of collecting system perforation. Safak et al. [19] showed that the perforation rate of collecting system caused by balloon dilations was slightly lower than sequential amplatz dilations, 11.60% (11/95) and 16.60% (5/30), respectively. In our study, 80 patients with staghorn renal stones who underwent balloon dilations had no serious complications such as blood transfusion and collecting system perforation.

Staghorn renal stones with refractory infections are often treated with staged operation [5]. However, staged operation may have some disadvantages in the treatment of staghorn renal stones with refractory infections. Kawahara et al. [20] speculated that if staghorn renal stones occupied the entire renal calices, even if PCNL succeeded using fluoroscopy or ultrasonography, it was difficult to get the guide-wire into the ureter before dilation. Rao et al. [21] discovered purulent fluid in the collecting system of six patients who underwent PCNL, and then six patients postponed PCNL after initiating antibiotic therapy and inserting nephrostomy tubes for some days. However, some renal calices containing purulent fluid may be blocked by staghorn renal stones, and a single nephrostomy tube seems unable to drain the purulent fluid of all the renal calices [22]. Aron et al. [5] believed that if multiple nephrostomy tubes were used for renal calices containing purulent fluid, no advantage may be seen in a staged procedure. Therefore, we urgently need to improve the operation plan, so as to effectively solve the intractable problem of staghorn renal stones with refractory infections. Calculous pyonephrosis was previously considered as a contraindication for PCNL, but in Wang's study, PCNL assisted by the third-generation EMS lithotripsy for one-phase treatment of calculous pyonephrosis was safe [23, 24].

The fifth-generation EMS integrates pneumatic energy, ultrasonic energy and negative pressure suction. For the fragmentation of staghorn renal stones, we used the fifth-generation EMS, applying pneumatic energy and ultrasonic energy together. At the same time, the fragmentation and removal of staghorn renal stones can be carried out through vacuum suction, which can avoid the transfer or even residue of small stone fragments. Therefore, EMS lithotripsy can crush stones with a high SFR. In our study, SFR of A group and B group was 81.25% and 84.38% respectively, and there was no statistically significant in SFR between the two groups ($P$ 0.05). Our study showed that PCNL combined with EMS lithotripsy was highly effective in one-phase treatment of staghorn renal stones with refractory infections. Usually, the surgeon should use high-pressure water pump to maintain a clear visual field during PCNL, which may lead to a significant increase in the pressure of the renal pelvis, allowing purulent fluid to flow back into the blood through the patient's collecting system. Bacteria, endotoxin and exotoxin can enter into the blood of patients by way of reflux, which leads to high fever, bacteremia and even SIRS after operation. For staghorn renal stones with pyonephrosis, EMS lithotripsy can effectively remove the purulent fluid in the collecting system by negative pressure suction. In addition, negative pressure suction is helpful to keep the patients in the state of negative pressure, which can effectively reduce the incidence of postoperative systemic infection. Patients with staghorn renal stones and UTIs can undergo urine culture before operation, and prophylactic antibiotics should be used according to the results of urine culture. These measures can effectively avoid the absorption of endotoxin, exotoxin, and pyrogens in patients, and

significantly reduce the chance of complications such as bacteremia, SIRS, and postoperative high fever. In A group and B group, there were 18 cases (37.50%) and 4 cases (12.50%) of WBC count (10 × $10^9$/L), 14 cases (29.17%) and 3 cases (9.38%) of CRP (≥ 8 mg/L), 17 cases (35.42%) and 4 cases (12.50%) of PCT (≥ 0.05 ng/mL) respectively ($P$ 0.05 for all); However, differences on Clavien-Dindo grade I complications (41.67% and 37.50%, respectively) and Clavien-Dindo grade II and above complications (6.25% and 0.00%, respectively) after operation between A group and B group were not statistically significant ($P$ 0.05). Our study revealed that, based on the application of sensitive antibiotics before operation to properly control refractory infections, PCNL combined with EMS lithotripsy in one-phase treatment of staghorn renal stones with refractory infections did not increase the risk of postoperative complications.

# Conclusions

Our research suggested that, for staghorn renal stones with refractory infections, based on the application of sensitive antibiotics before operation to properly control refractory infections, PCNL assisted by the fifth-generation EMS lithotripsy in one-phase can efficiently remove staghorn renal stones, without increasing the risk of postoperative complications. In the medical center with mature technical conditions and rich experience, staghorn renal stones with refractory infections can be selected carefully to carry out one-phase operation.

# Abbreviations

PCNL, Percutaneous nephrolithotomy

UTI, Urinary tract infection

EMS, Electro Medical System

SFR, Stone-free rate

US, Ultrasound

KUB, Plain film of kidney-ureter-bladder

CT, Computed tomography

BMI, Body mass index

SA, Surface area

WBC, White blood cell

CRP, C-reactive protein

Hb, Hemoglobin

ESWL, Extracorporeal shock wave lithotripsy

FURL, Flexible ureteroscopy lithotripsy

PCT, Procalcitonin

SIRS, Systemic inflammatory response syndrome

## Declarations

# Ethics approval and consent to participate

The study was approved by the Ethics Committee of Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine (reference number: XHEC-D-2020-101). Verbal consents were obtained from all the participants, because all the information was required from historic electronic records, and no any identified information is showed in the article. The study conforms to the Declaration of Helsinki.

# Consent for publication

Not applicable.

# Availability of data and materials

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

# Competing interests

The authors declare that they have no competing interests.

# Funding

This study was supported by Shanghai Municipal Commission of Science and Technology Grant (grant no. 17441905602).

# Authors' contributions

YH performed surgical procedures. HT, DW, BS and ZD collected and analyzed the data. HT wrote the manuscript. HT, DW and BS corrected the language of the paper. All authors read and approved the final manuscript.


# Acknowledgements

Not applicable.


# Authors' information


Haixiao Tang, Email: tanghaixiao12138@163.com

Di Wu, Email: wu-di@hotmail.com

Bowen Shi, Email: shibowen2015@126.com

Zehao Dai, Email: daizehao1996@163.com

Yunteng Huang, Email: huangyunteng@xinhuamed.com.cn


# References


1. Preminger GM, Assimos DG, Lingeman JE, Nakada SY, Pearle MS, Wolf JS Jr, et al. Chapter 1: AUA guideline on management of staghorn calculi: diagnosis and treatment recommendations. J Urol. 2005;173:1991–2000.
2. Diri A, Diri B. Management of staghorn renal stones. Ren Fail. 2018;40:357–62.
3. Healy KA, Ogan K. Pathophysiology and management of infectious staghorn calculi. Urol Clin North Am. 2007;34:363–74.
4. El-Nahas AR, Elshal AM, El-Tabey NA, El-Assmy AM, Shokeir AA. Percutaneous nephrolithotomy for staghorn stones: a randomised trial comparing high-power holmium laser versus ultrasonic lithotripsy. BJU Int. 2016;118:307–12.
5. Aron M, Goel R, Gupta NP, Seth A. Incidental detection of purulent fluid in kidney at percutaneous nephrolithotomy for branched renal calculi. J Endourol. 2005;19:136–9.
6. Bianchi G, Marega D, Knez R, Bucci S, Trombetta C. Comparison of an electromagnetic and an electrohydraulic lithotripter: Efficacy, pain and complications. Arch Ital Urol Androl. 2018;90:169–71.
7. Radfar MH, Basiri A, Nouralizadeh A, Shemshaki H, Sarhangnejad R, Kashi AH, et al. Comparing the Efficacy and Safety of Ultrasonic Versus Pneumatic Lithotripsy in Percutaneous Nephrolithotomy: A Randomized Clinical Trial. Eur Urol Focus. 2017;3:82–8.
8. Jeon SS, Hyun JH, Lee KS. A comparison of holmium: YAG laser with Lithoclast lithotripsy in ureteral calculi fragmentation. Int J Urol. 2005;12:544–7.

9. Chen J, Zhou X, Chen Z, Liu L, Jiang L, Chen C, et al. Multiple tracts percutaneous nephrolithotomy assisted by LithoClast master in one session for staghorn calculi: report of 117 cases. Urolithiasis. 2014;42:165–9.
10. Chiang PH, Su HH. Randomized and prospective trial comparing tract creation using plasma vaporization with balloon dilatation in percutaneous nephrolithotomy. BJU Int. 2013;112:89–93.
11. Xiong J, Shi Y, Zhang X, Xing Y, Li W. Chinese One-shot Dilation versus Sequential Fascial Dilation for Percutaneous Nephrolithotomy: A Feasibility Study and Comparison. Urol J. 2019;16:21–6.
12. Wang Y, Jiang F, Hou Y, Wang Y, Chen Q, Zhang H, et al. Doppler ultrasound and X-ray-guided percutaneous nephrolithotomy with one-step balloon dilation for complex renal stones. Urol Int. 2013;91:326–30.
13. Javali T, Pathade A, Nagaraj HK. A Novel method of ensuring safe and accurate dilatation during percutaneous nephrolithotomy. Int Braz J Urol. 2015;41:1014–9.
14. Zhou T, Chen G, Gao X, Zhang W, Xu C, Li L, et al. 'X-ray'-free balloon dilation for totally ultrasound-guided percutaneous nephrolithotomy. Urolithiasis. 2015;43:189–95.
15. Özçift B, Bal K, Dinçel Ç. A comparison of balloon and amplatz dilators in percutaneous nephrolithotomy: a retrospective evaluation. Turk J Urol. 2013;39:226–331.
16. Arslan B, Akbulut MF, Onuk O, Küçüktopçu O, Çilesiz NC, Ozkan A, et al. A comparison of Amplatz dilators and metal dilators for tract dilatation in mini-percutaneous nephrolithotomy. Int Urol Nephrol. 2017;49:581–5.
17. Yamaguchi A, Skolarikos A, Buchholz NP, Chomón GB, Grasso M, Saba P, et al. Operating times and bleeding complications in percutaneous nephrolithotomy: a comparison of tract dilation methods in 5,537 patients in the Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study. J Endourol. 2011;25:933–9.
18. Yang L, Lu S, Han X, Wei P, Yang J, Hao T. Clinical Comparison of the Efficiency and Security of Balloon Dilators Versus Fascial Dilators in Percutaneous Nephrolithotripsy (PCNL). Pak J Med Sci. 2016;32:635–40.
19. Safak M, Gögüş C, Soygür T. Nephrostomy tract dilation using a balloon dilator in percutaneous renal surgery: experience with 95 cases and comparison with the fascial dilator system. Urol Int. 2003;71:382–4.
20. Kawahara T, Ito H, Terao H, Ogawa T, Uemura H, Kubota Y, et al. Ureteroscopy assisted retrograde nephrostomy for complete staghorn renal calculi. Curr Urol. 2012;6:102–5.
21. Rao PN, Dube DA, Weightman NC, Oppenheim BA, Morris J. Prediction of septicemia following endourological manipulation for stones in the upper urinary tract. J Urol. 1991;146:955–60.
22. Hosseini MM, Basiri A, Moghaddam SM. Percutaneous nephrolithotomy of patients with staghorn stone and incidental purulent fluid suggestive of infection. J Endourol. 2007;21:1429–32.
23. Wang J, Zhou DQ, He M, Li WG, Pang X, Yu XX, et al. One-phase treatment for calculous pyonephrosis by percutaneous nephrolithotomy assisted by EMS LithoClast master. Chin Med J (Engl). 2013;126:1584–6.

24. Liang T, Zhao C, Wu G, Tang B, Luo X, Lu S, et al. Multi-tract percutaneous nephrolithotomy combined with EMS lithotripsy for bilateral complex renal stones: our experience. BMC Urol. 2017;17:15.