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Safety and efficacy of Chinese minimally invasive percutaneous nephrolithotomy in the management of renal stones ≤ 2 cm: a single-center experience

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Abstract

Background: The goal for using smaller caliber instruments in PNL was to reduce the access-related complications and to decrease morbidity. The objective of this study was to evaluate the safety and efficacy of Chinese minimally invasive percutaneous nephrolithotomy (MIPNL) in the treatment of renal stones ≤ 20 mm.

Results: Sixty-seven patients completed the study protocol. The mean age was 41.10 ± 13.99 years (range 18–68 years). There were 43 (64%) male and 24 (36%) females. The mean stone size was ranged from 78.5 to 439.6 mm² (mean \pm SD 172.48 ± 69.54 mm²). The overall SFR was (82%). Twelve (18%) needed post-MIPNL auxiliary procedure, in the form of second MIPNL in 3 (4.5%) cases, SWL in 7 (10%), and RIRS in 2 (3%) cases. The intraoperative complication was present in four patients (5%) include bleeding necessitate blood transfusion in one patient (1.5%) and renal collecting system perforation 3 (4.5%). The postoperative complication was urine leakage 5 (7.5) and fever in 6 (9%) of patients.

Conclusion: Chinese MIPNL is safe and effective method for treatment of renal stone ≤ 20 mm size with satisfactory SFR and low complication rate when SWL failed or contraindicated. It is considered a feasible treatment alternative to standard PNL, in the absence of flexible URS or miniature nephroscope.

Keywords: Renal stone, Minimally invasive percutaneous nephrolithotomy, Extracorporeal shockwave lithotripsy, Ureteroscopy, Stone-free rate

1 Background

Various treatment options are available for renal stones and several factors are weighted in determining the optimal treatment protocol. Although the nature of stone and patient's medical condition appear to be the main factors, other factors as equipment availability, expertise, patients' preference, procedure morbidity, and therapeutic outcome as well as factors related to economy must be considered as well [1, 2].

Standard percutaneous nephrolithotomy (PNL) is known to have higher clearance rates for stones 1–2 cm.

Despite its high clearance rate, PNL is frequently considered a second-line therapy for several reasons, including procedure-related hemorrhages requiring a blood transfusion or intervention; also, in real-life practice, the usual 26/30 Fr tract size of PNL may be too large in the pediatric system and in some adult non-dilated systems. This has brought the need of using a smaller size tract [3, 4].

In 1990s, some Chinese urologists performed PNL through a small tract measuring 14–18 Fr by using an 8/9.8 Fr rigid ureteroscope and named it Chinese minimally invasive PNL (MIPNL) [5]. The goal for using smaller caliber instruments in PNL was to reduce the access-related complications and to decrease morbidity [6].

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In the present study, we reported our experience with the safety and efficacy of Chinese MIPNL in treatment of renal stone ≤ 20 mm under some selective criteria “extracorporeal shockwave lithotripsy (SWL) failure or contraindication.”

2 Methods

This hospital-based, prospective, interventional study was carried out during the period from December 2015 to March 2018. All adult patients presented with renal stones less than 20 mm size, in whom SWL failed or contraindicated, were eligible for participation. The study protocol was approved by the research ethical committee of our institution, and all patients provided a written informed consent before inclusion. Patients with severe musculoskeletal abnormalities, active urinary tract infection, renal congenital anomalies, and coagulation disorders were excluded from the study.

Patients were evaluated by medical history taking, physical examination, laboratory investigation including urine analysis with urine culture, complete blood count, serum creatinine and coagulation profile, and renal ultrasonography. The diagnosis of renal stone was based on non-contrast computed tomography (NCCT) that was performed preoperatively in all cases.

2.1 Chinese MIPNL procedure

All procedures were performed under general anesthesia. With the patient in lithotomy position, a ureteric catheter was endoscopically inserted into the ipsilateral ureter for retrograde pyelography and visitation of pelvicalyceal system. With the patient in the prone position and under fluoroscopy guidance, the targeted calyx was punctured using 18-gauge needle. Tract dilation was serially performed using Alken metal dilators from 8 Fr to 15 Fr, and a matched 16 Fr Amplatz sheath was placed. The stones were fragmented with holmium laser or pneumatic lithotripter through an 8/9.8 Fr rigid ureteroscope (Richard Wolf, Karl Storz, Germany). The big fragments were removed with a stone forceps, while small fragments (< 3 mm) were removed by a combination of forceful retrograde saline flushing through the ureteric catheter and the effect of pulsatile irrigation through the sheath. Finally, a matched size nephrostomy tube (12 or 14 Fr) was inserted into the collecting system. If indicated, a double-J ureteral stent was inserted via the percutaneous tract under fluoroscopy with the assistance of guide wire.

2.2 Data collection and outcome measures

In all cases, serum creatinine, complete blood count, and abdominal pelvic ultrasonography were performed at the second postoperative day, and NCCT was performed at the postoperative week 2. The primary outcome measure was the stone-free status as detected by NCCT. Patient

with no stone or residual fragment(s) < 4 mm was considered stone free. The secondary outcome measures were the operative time, fluoroscopy time, intra- and postoperative complication, and need for auxiliary procedure.

2.3 Data analysis

Statistical package for social sciences (SPSS) ver. 21 (IBM cooperation New York, NY, USA) software was used for statistical analysis. The categorical data were presented in the form of number (percentage) and numerical data in the form of median or mean \pm standard deviation (SD) and range. Sample size calculation was performed.

3 Results

Sixty-seven patients completed the study protocol; there were 43 (64%) males and 24 (36%) females, ranged in age from 18 to 68 years (mean 41.10 ± 13.99 years). The stone size ranged from 10 to 20 mm (mean 14.17 mm). The demographics data and clinical characteristics of studied patients as well as the preoperative radiologic findings are summarized in Table 1.

After initial MIPNL, 55 (82.0%) patients were rendered stone free. From them, 50 (74.6%) had no stone and 5 (7.5%) had clinically insignificant residual fragment(s). The operative time ranged from 40 to 190 min (mean 74.58 ± 30.34 min). The hospital stays ranged from 2 to 7 days (mean 3.34 ± 1.62 days).

Double-J ureteral stent was inserted in four (6%) patients. It was due to pelvic perforation in three (4.5%) patients, and single functioning kidney in one.

In the 12 (18%) patients with failed MIPNL, second MIPNL was performed in 3 (4.5%), SWL in 7 (10%), and retrograde intrarenal surgery (RIRS) in 2 (3%) cases.

As shown in Table 2, the intraoperative complication was reported in 4 (5.0%) patients. It was in the form of bleeding requiring blood transfusion in one (1.5%) and perforation of renal collecting system in 3 (4.5%). The reported postoperative complication was urine leakage in 5 (7.5%) patients and postoperative fever 6 (9.0%).

4 Discussion

SWL generally is considered to be the first-line therapeutic option for most renal stones < 2 cm [7, 8]. SWL outcome are influenced by stone composition, the lower calyceal angle that permits the clearance of the resultant residuals, and the patient's body habits, which may decrease the efficacy of SWL and increase the re-treatment rate [9].

In the present study, Chinese minimally invasive (MIPNL) is defined as a PNL technique with small working sheath, which is performed using an 8–9.8 Fr URS through a 16 Fr percutaneous renal access tract, this is technique was used also by other [10, 11].

Table 1 The demographics data, clinical characteristics, and preoperative radiologic findings

Variables	
Age (years)	
Range	18–68 years
Mean ± SD	41.10 ± 13.99 years
Gender [n (%)]	
Male	43 (64)
Females	24 (36)
Laterality [n (%)]	
Right kidney	32 (48)
Left kidney	35 (52)
Stone size (burden) (mm ²)	
Range	78.5–439.6 mm ²
Mean ± SD	172.48 ± 69.54 mm ²
Stone radio-opacity [n (%)]	
Radio-opaque	56 (83.6)
Radio-lucent	11 (16.4)
Stone density on NCCT, HU	
Range	460–1650 HU
Mean ± SD	1022 ± 315 HU
History of urolithiasis [n (%)]	
Denovo stone	31 (46.3)
Recurrent stone	36 (53.7)
Indication of MIPNL [n (%)]	
SWL failure	44 (66)
Stone in a closed calyx	7 (10)
Patients' preference	16 (24)
State of P/C system [n (%)]	
Normal	32 (47.8)
Dilated	35 (52.2)
Mild	22 (32.8)
Moderate	9 (13.4)
Severe	4 (6.0)

HU Hounsfield unit, MIPNL mini-percutaneous nephrolithotomy, NCCT non-contrast computed tomography, SWL shockwave lithotripsy, SD standard deviation, n number

Table 2 Intra- and postoperative complications

Complications	N (%)
Intraoperative complications	
Bleeding	1 (1.5)
Pelvic perforation	3 (4.5)
Postoperative complications	
Urine leakage	5 (7.5)
Fever	6 (9.0)

In our study, the overall stone-free rate (SFR) after MIPNL was (82%). This result are comparable to results published by Li et al. [12] Huang et al. [10], and Giusti

et al. [13] who reported the SFR of 83.9%, 85.4%, and 77.5%, respectively.

The only reported major intraoperative complication is the bleeding in one patient 1.5%, that needed blood transfusion; these results are less than to those reported by Huang et al. [10], who reported bleeding in four patients (9.8%) with only one patient (2.4%) requiring blood transfusion.

Pelvicalyceal perforation was reported in three patients (4.5%). Zhong et al. [10] reported pelvic perforation in two patients (6.9%), and on the other hand, Hung et al. [14] and Knoll et al. [15] reported no pelvic perforation in any of patients during MIPNL procedure.

Leakage and fever were the most common postoperative complications in five patients (7.5%) and six patients (20%), respectively. Hung et al. [10] reported leakage in two patients (4.9%) and fever in five patients (12.1%), and Lu et al. [11] reported leakage in 3.1% and fever in 15.6% post-MIPNL.

The use of auxiliary procedures such as SWL, RIRS, and second PNL may be necessary to achieve high SFR. The possibility of needing such auxiliary procedure to achieve a satisfactory outcome should be explained to the patients.

In our study, because of 12 (18%) patients with failed MIPNL, second MIPNL was performed in 3 (4.5%) cases, SWL in 7 (10%), and RIRS in 2 (3%) cases. De Le et al. [16], Hung et al. [10], and Monga et al. [17] reported auxiliary procedure post-MIPNL in 21.4%, 14.6%, and 9.5%, respectively.

The body mass index of our patients did not make a significant difference nor need special modifications in our tools in order to complete our procedure. Sometimes only, it consumes more time in positioning and more effort for successful puncture in such patients with high BMI.

The learning curve of a single surgeon suggests that competence at performing classic PNL is an important step to make learning curve of this technique better and faster. However, it needs some more time than classic PNL due to difficulties related to vision, diminished irrigation, and limited field.

We named some limitations in our study. Firstly, this was a study about a small group of patients. Secondly, it was the early experience of our center in practicing this technique. Thirdly, there is need for comparison with other procedures like RIRS.

There were some difficulties that faced us and caused decreased SFR, the diminished intraoperative field visibility (especially when patient had bleeding), the need for fragmentation into very small stones suitable for ureteroscopic graspers and/or baskets, and the small sheath.

5 Conclusion

Chinese MIPNL is safe and effective method for treatment of renal stone ≤ 20 mm size with satisfactory SFR and low complication rate when SWL failed or contraindicated. It is considered a feasible treatment alternative to standard PNL, in the absence of flexible URS or miniature nephroscope.

Abbreviations

PNL: percutaneous nephrolithotomy; MIPNL: minimally invasive percutaneous nephrolithotomy; NCCT: non-contrast computed tomography; BMI: body mass index; SFR: stone-free rate; SWL: shock wave lithotripsy; URS: ureteroscopy; RIRS: retrograde intrarenal surgery.

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Not applicable.

Authors' contributions

ES contributed to protocol development, data collection, and manuscript writing. IE contributed to data collection and manuscript editing. HE collected and analyzed data. ME contributed to data analysis and manuscript writing. MM contributed to data analysis and manuscript revision. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available because that is the policy of our university but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

In this study, all procedures performed involving human participants were in accordance with the ethical standards of our institution; faculty of medicine, Al-Azhar university and approved by tow ethical committee the first one in the ethical committee of urology department and the other in the ethical committee of faculty of medicine. At that time, there was no number to be given to the study but after that the numbering system became routine. The informed consent obtained from study participants was written.

Consent for publication

Not Applicable.

Competing interests

The authors declare that they have no competing interests.

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