Med. J. Cairo Univ., Vol. 86, No. 8, December: 4525-4529, 2018
www.medicaljournalofcairouniversity.net

Minimally Invasive Percutaneous Nephrolithotomy in Management of Lower Pole Renal Stones 2cm or Less

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Abstract

Background: The best management of lower calyceal stones remains debatable. Small lower calyceal stones are usually managed with SWL, RIRS or PNL.

Aim of Study: This study aims to assess the safety, efficacy and complications of minimally invasive percutaneous nephrolithotomy (mini PNL) in lower calyceal stones.

Patients and Methods: Patients with lower calyceal radiopaque unilateral stones ≤2cm were enrolled and underwent mini PNL between February 2014 and January 2016 using a semi rigid ureteroscope through a 16Fr sheath and holmium laser lithotripsy. Patients were considered stone free when no stones or residuals <3mm were found on plain X-ray UT or non contrast CT.

Result: Thirty patients with mean age of 40±9.2 years underwent mini PNL for lower calyceal stones ranging in size from 10-20mm (16.1 ± 1.8). A single tract was used (16Fr). Six patients (20%) had a nephrostomy tube (12F) at the end of the procedure. Mean hospital stay was 2±0.15 days. Twenty-five (83.3%) of our patients had no or mild post-operative pain that required no analgesia. Minor complications occurred in 4 patients (13.3%) in the form of post-operative fever and was treated conservatively.

Conclusion: Mini PNL is a safe and effective treatment option for lower calyceal stones 2cm or less. Mini PNL is limited by longer operative time than standard PNL. It has similar safety profile as of standard PNL with the advantage of causing significantly less pain and shorter hospital stay. Stone Free Rate (SFR) is comparable to PNL and is significantly better than SWL and possibly RIRS.

Key Words: *Stone – Lower calyx – Minimally invasive – Percutaneous – Nephrolithotomy.*

Introduction

THE best management of lower calyceal stones remains debatable. Small lower calyceal stones are usually managed with SWL, RIRS or PNL. An established minimally invasive treatment option for removal of kidney stones is PNL especially with renal calculi bigger than 30mm in diameter. [1] . However, mini PNL offers an accepted alternative management that reduces the invasiveness of conventional PNL and better than SWL which often leads to persistent residual stone fragments [2] .

In this study, we assessed the safety, efficacy and outcome of mini-Perc in management of lower calyceal renal stones 2cm or less in an adult population, and to compare the results with outcomes of Retrograde Intra Renal Surgery (RIRS) and Shockwave Lithotripsy (SWL) in matched patients.

Patients and Methods

This prospective non-randomized clinical trial was done in Kasr Al-Ainy Hospital between February 2014 and January 2016. Thirty patients with radiopaque stones located in the lower pole of the kidney either single or multiple stones with sum of ≤2cm in maximum diameter were included.

All patients were subjected to full history taking, physical examination, laboratory investigations [Complete Blood Count (CBC), coagulation profile, kidney function tests, liver function tests, random blood sugar, urine analysis and urine culture if needed] and imaging studies (abdomino-pelvic ultrasound, KUB and either intravenous urography or computed tomography of the urinary tract). A written informed consent was taken prior to surgery.

Data about stone site, size, shape and number were recorded. Operative time, size of tract, type of dilators used, type of lithotripter and if nephrostomy tube was placed or not at the end of the procedure were collected.

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Patients were asked to fast 6-8 hours before the operation. During induction with general anaesthesia a third-generation cephalosporin antibiotic was given after doing sensitivity test. Patients were positioned in lithotomy position on a fluoroscopy compatible operative table. Cystoscopy was done, and the ipsilateral ureteric orifice was identified, an open-tipped ureteric catheter (6 or 7Fr) was passed into the pelvicalyceal system over a hydrophilic straight tipped guide wire (0.038 inch). The ureteric catheter was secured to the Foley catheter. Once the ureteric catheter was fixed, the patient was placed in prone position. Bolsters were placed under the anaesthesiologist's supervision to facilitate ventilation and avoid dislodgment of the endotracheal tube. Patients were prepped with povidone iodine and sterile surgical drapes were used while making sure of easy access to the distal end of the ureteral catheter for contrast material injection.

A sterile drape was applied to the C-arm's receiver. Percutaneous access was obtained by the placement of an 18-gauge access needle into the lower calyx harbouring the stones under real-time X-ray guidance. A J tipped curved guide wire (0.038 inch) was placed via the needle into the collecting system. A small incision was made with an 11-blade scalpel and the needle was removed.

Nephrostomy tract dilation was performed either using the first three Alken dilators or using Teflon Amplatz dilators up to 16Fr that can pass a 16Fr renal access sheath into the collecting system. We used a 9.5Fr ureteroscope (Wolf) through the renal access sheath. Fragmentation of the stones was done using Holmium laser lithotripsy. Stones were dusted with Holmium laser using low pulse energy and high frequency settings and most stone fragments could be flushed out along with the backflow through the sheath, while the remaining big fragments were extracted with stone forceps. All possible calyces were systematically inspected to evaluate for residual fragments. X-ray fluoroscopy was used at the end of the procedure to check for the presence of any residual fragments. At the end of the procedure, the decision to put a nephrostomy tube or not was left for the operator.

Intraoperative complications including bleeding, parenchymal injury, extravasation, calyceal neck injury, stone migration, incomplete stone removal, adjacent organ injury and blood transfusion were also recorded.

Post-operative pain, fever, hematuria and extravasation were noticed and recorded. All patients had post-operative CBC, serum creatinine and plain X-ray UT (KUB) on the first post-operative day. Data regarding the time of nephrostomy tube removal, need for analgesia and hospital stay were recorded. Post-operative pain was assessed by 0-10 numeric rating scale for pain (Table 1).

Follow-up was done at one and three months post-operatively in the form of urinalysis, KUB and NCSCT. SFRs and the need for auxiliary procedures were also reported.

Numerical data were statistically described in terms of mean ± Standard Deviation (SD), and range, while categorical data were described using frequencies (number of cases) and percentages. All statistical calculations were done using the computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows. The local ethical committee approved this study.

Table (1): Numeric rating scale for pain.

0	No pain
1-3	• Mild pain (nagging, annoying, interfering little with [ADLs]).
4-6	• Moderate pain (interferes significantly with ADLs).
7-10	• Severe pain (disabling; unable to perform ADLs).

ADL: Activities of Daily Living.

Results

Thirty patients were included in this study, seventeen patient (56.7%) were males while thirteen (43.3%) were females. Mean patients' age was 40±9.2 years (range 25-57). Mean Body Mass Index (BMI) was 29.2±3.1 (range 24.8-34.8kg/m^2).

Fourteen patients (46.7%) had history of failed SWL on the same existing stones. Eight patients (26.7%) had history of stone surgery (either pyelolithotomy or PNL), seven of them (23.3%) on the same side of the existing stone. Two patients (6.7%) were diabetic, two patients (6.7%) had hepatitis C virus and one patient (3.3%) had hypertension.

Twenty-one patients (70%) had a culture-proven urinary tract infection. The mean pre-operative Hemoglobin (Hb) was 12.7±1.4g/dl and the mean preoperative creatinine was 1.02±0.28mg/dl. Twenty-five patients (83.3%) had a single stone, four patients (13.3%) had two stones, while one patient (3.3%) had three stones. Stones size ranged from 10 to 20mm in maximal diameter with mean 15.47 ±3.04mm (in case of multiple stones the whole stone burden is 20mm or less).

The stones were on the right side in seventeen (56.7%) patients and in thirteen (43.3%) patients on the left side. Mean operative time was 50.67 ± 23.3 minutes starting from ureteric catheter insertion till end of procedure. Alken dilators were used in twenty five patients (83.3%) while Amplatz dilators were used in five patients (16.7%). In one patient (3.3%), a small perforation was seen in the renal pelvis (fatty tissue appeared mostly from dilatation of the tract by Alken dilators) at the end of the procedure and required postoperative PCN for 2 days.

None of our patients developed intra operative bleeding, adjacent organ injury, calyceal neck injury, stone migration or sepsis. Twenty-four patients (80%) had a tubeless procedure while 6 patients (20%) had a nephrostomy tube (12F) at the end of the procedure. One patient (3.3%) had DJ fixation at the end of the procedure in addition to a nephrostomy tube as he had a solitary kidney. Operative parameters are detailed in (Table 2).

Twenty-nine patients (96.7%) were stone free on KUB at the first postoperative day while one patient (3.3%) had a residual stone (4mm). The mean postoperative Hb was 12.2 ± 1 .3g/dl, the mean Hb loss was 0.48g/dl. The mean post-operative creatinine was 1.04±0.2mg/dl. Post-operative fever occurred in four patients (13.3%) and was treated conservatively. None of our patients required post-operative blood transfusion or suffered leakage from PNL site or after removal of nephrostomy tube. Three patients (10%) had no pain (score 0), twenty two patients (73.3%) had mild pain (score 1-3), five patients (16.7%) had moderate pain (score 4-7) and none of our patients had severe pain (score 7-10). Post-operative analgesia (in the form of NSAID's) was given in ten patients (33.3%) while twenty patients (66.7%) did not require analgesia.

Mild post-operative hematuria occurred in twenty seven patients who were managed conservatively with IV fluids while three patients (10%) had no gross hematuria [gross hematuria was classified based on colour into mild (rose), moderate (dark red), severe (dark red with blood clots)]. The mean hospital stay was 1.7 ±0.6 days. Twelve patients (40%) were discharged during the first post-operative day, all of them had tubeless procedure and received no analgesia.

After one month, twenty sex patients (86.7%) had normal urinalysis while four patients (13.3%) had a culture-proven infected urine. Follow-up after one month with NCCT revealed twenty nine patients (96.7%) were stone free while one patient (3.3%) had small residual stone (4mm) which required post-operative SWL. After 3 months, all patients were stone free based on KUB findings.

Table (2): Operative parameters.

Operative parameters	
• *Type of anesthesia:*	
General	30/30 (100%)
• Time (min)	50.67±23.3 (20-100)
• *Dilators:*	
Alken	25/30 (83.3%)
Amplatz	5/30 (16.7%)
• *Size of the tract:*	
16F	30/30 (100%)
• *Lithotripsy:*	
Laser	30/30 (100%)
• *Nephrostomy tube:*	
Tubeless	24/30 (80%)
PCN	6/30 (20%)
• Use of DJ	1/30 (3.3%)

Discussion

Different procedures are available for the management of lower calyceal renal stones including SWL, RIRS and PNL. The least invasive procedure in stone treatment is SWL. It has a short-term and long-term SFR of 67%-93% and 57%-92%, respectively, with a re-treatment rate of 13.9%-53.9% [3]. A safe but more invasive procedure than SWL is PNL. It has a higher complication rate related to access tract number and size [4]. RIRS is accepted for the treatment of moderate sized stones with an excellent SFR while avoiding the morbid complications of PNL [5]. Thus for lower calyceal stones, it is still debatable which procedure is the best option for management [6].

Mini PNL offers an accepted alternative management option, as SWL often leads to persistent residual stone fragments, whereas conventional PNL achieves a higher stone-free rate and allows a shorter treatment period but with a somewhat higher surgical risk [2].

A number of authors have studied this option. Kumar et al., 2013 included single stones only, 1-2cm in maximal diameter with mean stone size of 13 .3± 1 .3mm, all stones were radiolucent [8]. Kruck et al operated on smaller stones; the mean stone size was 12.6± 1.2mm [9].

Different tract sizes were reported in literature together with different techniques for tract dilatation

and stone disintegration. Mishra et al., reported a tract size of 14-18F using fascial dilators in a stepwise manner. Nephroscopy was done using a miniature nephroscope (12/14F) together with the holmium laser in nineteen cases (70.4%), lithovac in six cases (22.2%) and ultrasonic lithotripter in 2 cases (7.4%) [10]. Akbulut et al., used Amplatz dilators up to 18F in all patients followed by nephroscopy with the 17F nephroscope together with the laser, pneumatic or ultrasonic lithotripter for stone fragmentation [7]. We used the Alken or Amplatz dilators to dilate a 16F tract. Nephroscopy was done with a 9.5F ureteroscope and holmium laser for stone disintegration.

The mean operative time was 50.67 ±23.3 minutes in our study which was comparable to other studies like Kumar et al., (61 ± 1.3 minutes) [8] and Mishra et al., (45.2 ± 12.6 minutes) [10] but this was shorter than other studies like Akbulut et al., where the mean operative time was 91.9 ±37.6 minutes [7].

A tubeless procedure was done in twenty four patients (80%) while six patients (20%) had a nephrostomy tube (12F) at the end of the procedure. Similarly, Mishra et al., who had a tubeless procedure in twenty one cases (77.8%) and six cases (22.2%) with a nephrostomy tube post-operatively [10] unlike Akbulut et al., who put a nephrostomy tube in all cases (100%) [7].

We had five minor complications (16.7%); four patients (13.3%) had fever and one patient (3.4%) had pelvic perforation, none of our patients had significant bleeding which required blood transfusion. This was slightly higher than Mishra et al., where complications occurred in three patients (11.1%) [two patients (7.4%) had fever and one patient (3.7%) had pelvic perforation] [10] but lower than other studies like Kumar et al., where complications occurred in ten patients (24.3%), [8] and Akbulut et al., who reported complications in 9 patients (29%) [7]. Nevertheless, all authors agreed that the incidence and extent of complications were acceptable.

Mean hospital stay was 1.7 ±0.6 (1-3) days which was shorter than many other studies like Akbulut et al., where the mean hospital stay was 2.7 ± 1.6 days, [7] Kumar et al., 3.1 days [8] and Mishra et al., 3.2 ±0.8 days [10]. This was mostly due to the large number of tubeless procedures and the relatively low complications. This may highlight the value of tubeless procedure being associated with less post-operative pain and shortened hospital stay.

We reported a Stone Free Rate (SFR) at one month of (96.7%). This was higher than some studies like Akbulut et al., where the SFR was (90.3%) [7] and Nagele et al., where the SFR was (92.9%) [2] and comparable to other studies like Kumar et al., where the SFR was (95.1%) [8] and Mishra et al., where the SFR was (96%) [10].

In a study of matching cohorts conducted by Salem et al., at our center in 2013, the SFRs for RIRS was 96.7% while SFRs for a similar group of patients who underwent SWL was much lower at 56.7% [11].

Points of strength in our study include the design being a prospective study and the accurate assessment for pain and need for analgesia following surgery using 0-10 Numeric Rating Scale for pain that is lacking in most of studies [7,8,10].

The main limitations in our study are the small sample size which limits statistical power and the fact that it is a single arm (non-comparative) study. We did not have adequate data regarding the stone composition, which could affect the surgical results. A possible additional limitation of our study was that the decision of a tubeless procedure was left to the operating surgeon.

Conclusion:

Mini PNL is a safe and effective treatment option for management of lower calyceal stones 2 cm or less in maximal diameter in an adult population. Mini perc is limited by longer operative time than standard PNL but ends more frequently in tubeless procedure because of significantly less bleeding. It has similar safety profile as of standard PNL and results in a comparable SFR, less post-operative pain and a shorter hospital stay. The combination of using the mini PNL technique with Holmium laser lithotripsy is very helpful in decreasing intra renal manipulations and thus decreasing the chance for subsequent injuries. Potential benefits of mini PNL over RIRS may include an easier learning curve and lower cost. SFR after mini PNL is significantly better than SWL and possibly RIRS.

Conflict of interest: None.

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إستخدام منظار الكلى المصغرة لإستخراج حصوات أقل من ٢سم من الكأس السفلى للكلى

العلاج الأمثل لحصوات الكأس السفلى للكلى يظل مثار للجدل حيث يمكن علاجها عن طريق تفتيت الحصوات بالموجات التصادمية أو عن طريق إستخدام منظار الحالب المرن والهولميون ليزر أو من خلال مناظير الكلى التقليدية أو المصغرة.

وتهدف هذه الدراسة لتقييم كفاءة وسلامة إستخدام مناظير الكلى المصغرة لإستخراج حصوات من الكأس السفلى للكلى أقل من ٢سم فى الحجم.

وقد تمت هذه الدراسة على ثلاثين مريض لديهم حصوات بالكأس السفلى للكلى أقل من ٢سم فى الحجم فى الفترة ما بين فبراير ٢٠١٤ وفبراير ٢٠١٦، وقد تم تفتيت الحصوات بإستخدام منظار الحالب شبه الصلب والهولميون ليزر أو التفتيت الهوائى من خلال مقاس ١٦ فرنش.

فى هذه الدراسة وجد نسبة النجاح فى إجراء عمليات منظار الكلى المصغرة لإستخراج حصوات من الكأس السفلى للكلى أقل من ٢سم بدون وجود حصوات متبقية قد بلغ ٩٦.٧٪.

وقد حدثت مضاعفات فى هذه الدراسة لخمسة مرضى بنسبة ١٦.٧٪ منهم أربعة مرضى عانوا من أرتفاع فى درجة الحرارة والمريض الخامس من ثقب فى حوض الكلى ولم يحتاج أى منهم لتدخل جراحى.

وقد أثبتت هذه الدراسة كفاءة وأمان إستخدام مناظير الكلى المصغرة لإستخراج حصوات الكلى من الكأس السفلى للكلى أقل من ٢سم وإعطاء بديل أمن للطريقة التقليدية لجراحات الكلى بالمنظار مع وجود نفس دواعى الأمن والأحتياطات والنتائج المرجوة. بالإضافة إلى أنها تعطى رضا وراحة أكثر بعد العملية ونسبة ألم أقل مما يؤدى إلى تقصير فترة الإقامة بالمستشفى بالمقارنة بالأساليب التقليدية وهذا يؤدى إلى تقليل التكلفة الإجمالية للمريض.