SJIF Impact Factor: 6.711

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

ISSN: 2457-0400
Volume: 9
Issue: 2
Page N. 212-217
Year: 2025

Original Article www.wjahr.com

MINI PERCUTANEOUS NEPHROLITHOTOMY IN THE TREATMENT OF KIDNEY STONES: A STUDY CONDUCTED AT A MEDICAL CENTER IN VIETNAM

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Article Received date: 23 December 2024 **Article Revised date:** 13 January 2025 **Article Accepted date:** 03 February 2025

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ABSTRACT

This study aims to assess the effectiveness and safety of mini percutaneous nephrolithotomy (mini-PCNL) in treating kidney stones. A combined retrospective and prospective descriptive study was conducted on 92 patients with kidney stones treated using mini-PCNL at Can Gio District Medical Center, Ho Chi Minh City, from January 2023 to June 2024. The procedure was performed under ultrasound guidance, utilizing a 16 Fr Karl-Storz nephroscope and holmium laser for stone fragmentation. Outcomes evaluated included the stone-free rate and postoperative complications. Of the 92 patients, 60 were male (65.2%) and 32 were female (34.8%), with an average age of 52 ± 11.76 years (range: 19–70). Single stones were present in 73.9% of cases, while 26.1% had multiple stones. Preoperative MSCT revealed no hydronephrosis or grade I hydronephrosis in 21.7% and 42.7% of patients, respectively, grade II in 28.3%, and grade III in 7.6%. The average stone length was 25.7 ± 5.9 mm, and the average width was 16.3 ± 2.5 mm. The mean operative time was 71.86 ± 15.09 minutes (range: 45–80 minutes). The postoperative stone-free rate was 79.3%, increasing to 90.2% at the one-month follow-up. Eighty patients were followed for an average of 20 ± 6 months. Two patients experienced ureteral stone fragments requiring retrograde ureteral lithotripsy, and one patient developed ureteral stenosis requiring double-J stenting. No cases of blood transfusion, renal atrophy, kidney failure, or sepsis were reported. The average postoperative hospital stay was 7.67 ± 3.21 days (range: 4–10 days). Mini-PCNL has been successfully implemented at Can Gio District Medical Center with promising initial outcomes, including a high stone-free rate, shorter hospital stays, and no significant complications. Further studies are recommended to comprehensively evaluate its safety and efficacy in managing larger kidney stones.

KEYWORDS: Mini percutaneous nephrolithotomy, kidney stone, minimal invasive procedure, medical center.

INTRODUCTION

Urolithiasis is a widespread medical condition affecting populations across the globe. In Vietnam, it is one of the most common urinary tract disorders, accounting for 45–50% of all cases, with kidney stones making up approximately 70–75% of these. The disease is most frequently observed in individuals between the ages of 30 and 60 and is more prevalent in men (60%) compared to women (40%).[1]

If left untreated, kidney stones can lead to various complications, including recurrent infections, obstruction of the urinary tract, impaired renal function, and, in severe cases, life-threatening conditions such as urosepsis or kidney failure. However, with continuous advancements in medical technology, interventional techniques for kidney stone treatment have significantly evolved, improving patient outcomes and reducing the need for invasive procedures.[2]

Percutaneous nephrolithotomy (PCNL), a minimally invasive technique for removing kidney stones, was first introduced by Fernstrom and Johanson in 1976. In the past, due to late diagnoses and the presence of complex stones - such as staghorn calculi - combined with secondary complications, open surgery was the dominant treatment approach in Vietnam, particularly for large stones. Although effective, open surgery was associated with longer hospital stays, higher complication rates, and greater post-operative discomfort.

Vietnam first implemented standard PCNL in 1997, using X-ray guidance and dilation systems with Amplatz sheaths ranging from 26 to 30 Fr. Over the past few decades, continuous improvements in surgical

instruments and techniques have led to the miniaturization of percutaneous nephrolithotomy, resulting in less invasive approaches such as mini-PCNL and MicroPerc. These innovations have helped to reduce complications, shorten recovery times, and expand treatment options for patients with varying stone sizes and anatomical conditions.

Today, mini-PCNL and MicroPerc have been widely adopted in major medical centers across Vietnam, including Viet Duc University Hospital, Binh Dan Hospital, and Hanoi Medical University Hospital.[3] Additionally, these techniques are gradually being introduced at provincial hospitals, increasing accessibility to advanced treatment nationwide. Since 2020, Can Gio Medical Center in Ho Chi Minh City has successfully applied percutaneous nephrolithotomy using an 18 Fr access sheath and an 80W holmium laser, further enhancing the precision, safety, and effectiveness of kidney stone treatment in Vietnam.

SUBJECTS AND METHODS

Subjects

This study was conducted on a total of 92 patients diagnosed with kidney stones who underwent mini-percutaneous nephrolithotomy (mini-PCNL) at Can Gio Medical Center, Ho Chi Minh City, between January 2023 and June 2024. The research aimed to evaluate the effectiveness, safety, and outcomes of the procedure, providing valuable insights into its application in clinical practice.

Before surgery, all patients underwent comprehensive preoperative assessments, including thorough clinical examinations and routine laboratory tests such as complete blood count, renal function tests, and coagulation profiles. Imaging studies were performed for all cases, including ultrasound and X-ray imaging of the urinary system to assess stone location and kidney structure. In addition, 100% of the patients underwent computed tomography (CT) urography, which allowed for a more detailed evaluation of stone morphology, size, and composition. CT urography also helped assess the anatomical relationships between the renal calyces and stones, detect any anatomical abnormalities in the urinary tract, and evaluate renal function, ensuring precise surgical planning and minimizing potential complications.

The patient selection criteria for this study included individuals diagnosed with kidney stones who met the indications for percutaneous nephrolithotomy and voluntarily consented to participate in the study. Only patients with complete medical records and preoperative assessments were included to ensure data integrity and accuracy. Patients with active urinary tract infections were not immediately eligible for surgery; they first underwent intensive antibiotic treatment, and only those who achieved negative urine culture results were cleared for the procedure. This protocol was essential to minimize the risk of post-operative infections and enhance surgical safety.

By adhering to strict selection and preparation protocols, the study ensured that all participants were optimally evaluated and managed before undergoing mini-PCNL. This approach allowed for a more accurate assessment of surgical outcomes while minimizing the risks associated with the procedure.

METHODS

All patients in this study underwent percutaneous nephrolithotomy (PCNL) using the Karl Storz mini-PCNL instrument set, which featured a dilator diameter of 16.5 Fr. This minimally invasive technique was performed under ultrasound guidance to enhance precision and reduce the risk of complications. The procedure was carried out using the Accutech Laser Lithotripter (ACU-H2G) with a maximum power output of 80W, ensuring effective fragmentation of kidney stones. A high-definition (HD) endoscopic system by Karl Storz was employed to provide clear intraoperative visualization, facilitating accurate stone removal.

To ensure optimal access to the renal collecting system, a Lunderquist Guidewire with a soft 5 cm tip and a stiff body was used for needle insertion. The tract was subsequently dilated using Amplatz plastic dilators ranging from 8 to 18 Fr, allowing for controlled and safe expansion. A nephrostomy catheter (6–7 Fr) was placed postoperatively to maintain drainage and monitor urine output. Additionally, a guidewire-assisted ureteral catheter was positioned to aid in urinary diversion, and a Double J stent was inserted to prevent obstruction and facilitate post-surgical recovery.

Throughout the procedure, an Accutech irrigation pump was utilized to maintain a clear surgical field. This system operated at a speed of 100–600 rpm, with an adjustable water pressure range of 0–80 kilopascals, ensuring efficient stone fragment clearance. A 0.9% NaCl irrigation solution was continuously used to optimize visibility and reduce thermal damage from laser lithotripsy.

Surgical procedure

After the administration of general anesthesia and endotracheal intubation, the patient was initially positioned in the lithotomy position to facilitate cystoscopy and the placement of a ureteral catheter into the kidney, preferably within the upper calyx. A urethral catheter was also inserted and securely positioned. Following this step, the patient was carefully repositioned into a 90° lateral decubitus position with contralateral lumbar support to provide optimal surgical access.

Ultrasound imaging was then employed to evaluate the renal pelvis, identify the stone-bearing calyx, and determine the most suitable puncture site. The selection

was based on the shortest distance from the skin to the calyx while ensuring access to other calyces for effective stone removal. Once the appropriate entry site was confirmed, a small skin incision was made, and tract dilation was performed using plastic dilators ranging from 6 to 18 Fr. Subsequently, an 18 Fr Amplatz sheath was advanced into the renal pelvis, allowing for the introduction of a nephroscope to visualize and assess the number and size of the stones.

Stone fragmentation was carried out using an 80W Holmium laser (Accutech), effectively breaking down the calculi into smaller fragments. Residual stones were thoroughly checked using both direct endoscopic visualization and ultrasound guidance. Once stone clearance was confirmed, a Double J stent was inserted, either in an antegrade or retrograde manner, depending on intraoperative feasibility. The nephroscope and Amplatz sheath were then carefully withdrawn, and a nephrostomy drain was placed at the surgeon's discretion. The patient was subsequently repositioned into the supine position to complete the procedure.

In the postoperative period, patients were closely monitored for early complications, with particular attention to urine output characteristics, including color and volume, from both the nephrostomy and urethral catheters. Postoperative blood tests were conducted to assess blood loss and overall patient stability. On the first postoperative day, both the urethral and ureteral catheters were removed. If the patient remained stable, the nephrostomy drain was clamped and subsequently removed after 24 to 48 hours. For patients experiencing flank pain or persistent urinary leakage from the nephrostomy site, additional urinary system X-ray imaging was performed. If residual stone fragments measuring ≥ 4 mm were detected, a Double J stent was inserted before proceeding with nephrostomy drain clamping and removal.

Patients were scheduled for a follow-up examination one month after surgery, during which X-ray imaging was conducted to assess stone clearance and facilitate the removal of the Double J stent. Cases in which patients failed to complete follow-up evaluations were excluded from the study to ensure accurate assessment of treatment outcomes.

RESEARCH RESULTS

Patient characteristics

The study included a total of 92 patients, consisting of 60 males (65.2%) and 32 females (34.8%). The average age of the patients was 52 ± 11.76 years, ranging from 19 to 70 years, with the highest prevalence observed in the 41–50 age group (31.5%).

Regarding medical history, 21 patients had previously undergone medical treatment for kidney stones, while 13 had a history of open nephrolithotomy on the same side. Additionally, 8 patients had undergone extracorporeal shock wave lithotripsy (ESWL), and 6 had a history of contralateral kidney stone surgery. The mean body mass index (BMI) of the study population was 22.48 ± 4.3.

Clinically, the most common symptom reported at the time of hospital admission was dull lumbar pain, which affected 77.2% of the patients, while renal colic was present in 8.7% of cases. These findings highlight the variability in clinical presentation among patients undergoing treatment for kidney stones.

The study analyzed the characteristics of kidney stones among the patients, revealing that 73.9% had a single stone, while 26.1% had two or more stones. In terms of location, the majority of stones were found either in the renal pelvis (33.7%) or in the renal pelvis combined with a single calyx group (42.4%), indicating a predominant distribution in these areas (Table 1).

Table 1: Stone Location and Morphology.

Group	Pure renal pelvis	Renal pelvis + 1 calyx group	Renal pelvis + 2 calyx group	Renal pelvis + 3 calyx groups	Calyceal stones	Total
Number of patients	31	39	17	3	2	92
%	33.7	42.4	18.5	3.3	2.2	100.0

Renal pelvis dilation varied among the patients, with 64.1% exhibiting either no dilation (21.7%) or grade 1 dilation (42.4%). Meanwhile, 28.3% of patients presented with grade 2 dilation, and a smaller proportion (7.6%) had grade 3 dilation, reflecting different levels of obstruction and potential impact on renal function (Table 2).

Table 2: Degree of renal dilation on ultrasound.

Group	No gilation	Grade 1 dilation	Grade 2 dilation	Grade 3 dilation	Total
Number of patients	20	39	27	7	92
%	21.7	42.4	28.3	7.6	100.0

Regarding stone size, the mean surface area was 9.59 ± 4.82 cm^2, with an average length of 2.57 ± 0.59 cm and a

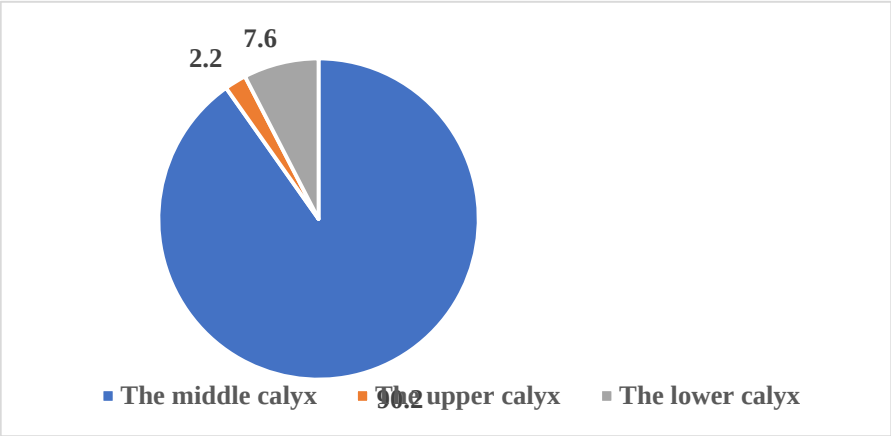
width of 1.63 ± 0.25 cm (Table 3). These measurements highlight the significant variation in stone dimensions among patients undergoing treatment.

Table 3: Stone size and surface area.

Characteristics	Smallest	Largest	Average
Length (cm)	1.65	4.64	2.57 ± 0.59
Width (cm)	1.08	2.37	1.63 ± 0.25
Surface Area (cm²)	1.86	22.29	9.59 ± 4.82

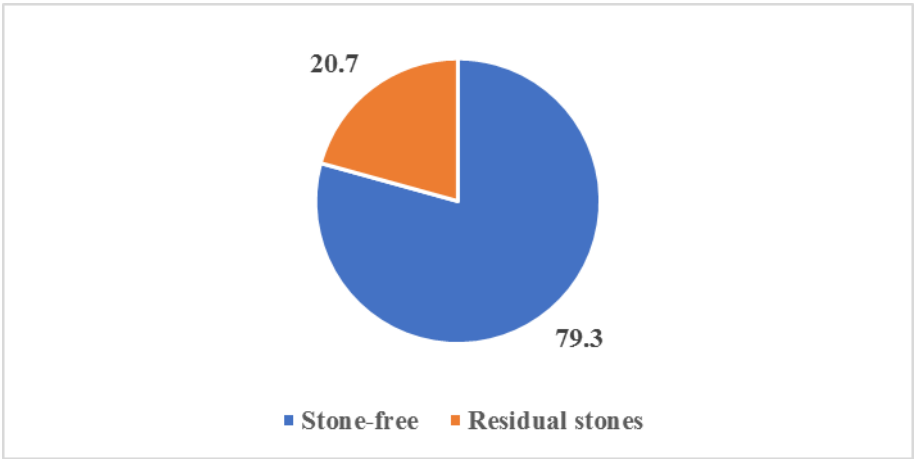
Surgical outcomes

The mean operative time was 71.86 ± 15.09 minutes, ranging from 45 to 112 minutes. Regarding the puncture site, the middle calyx was the most commonly used, with 83 patients (90.2%) having the puncture performed there. The upper calyx was used in 2 patients (2.2%), while the lower calyx was chosen for 7 patients (7.6%).



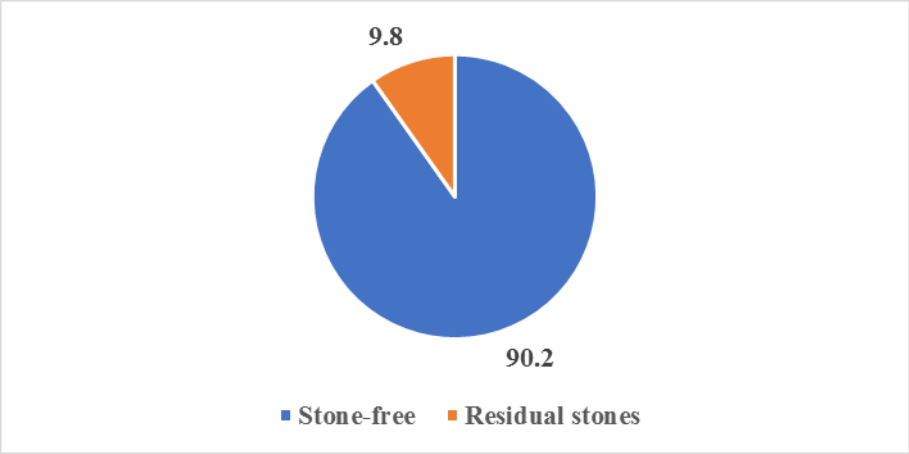
Firgue 1: The puncture site.

The immediate postoperative stone-free rate was 79.3%, with 73 patients achieving complete stone clearance. However, 20.7% of patients, or 19 individuals, had residual stones after the procedure. Of these, 9 patients (9.8%) underwent a second percutaneous nephrolithotomy (PCNL), and 6 of them achieved stone-free status. The remaining 10 patients (10.9%) had small residual stone fragments and were managed conservatively.



Firgue 2: Postoperative stone-free status.

During the one-month follow-up, all patients reported no pain or fever. Additionally, 83 out of 92 patients (90.2%) were confirmed to be stone-free after one month, while 9 patients (9.8%) continued to have small residual stones and were advised to follow up further.



Firgue 3: Stone-free status one month post-surgery.

There were no major complications reported during the study, such as injury to adjacent organs, significant intraoperative bleeding, or the need for conversion to open surgery. The mean intraoperative hemoglobin loss was 16.25 ± 8.5 g/L. The average duration of nephrostomy drainage was 4.20 ± 1.96 days, with a range of 2 to 12 days. The mean hospital stay was 7.67 ± 3.21 days, with a range of 2 to 17 days.

80 patients were followed up for an average of 20 ± 6 months after their surgery. During this period, late complications were observed in a few cases. 2 patients experienced migration of stone fragments to the ureter and required retrograde ureteroscopy for treatment. 1 patient developed a ureteral stricture, necessitating endoscopic dilation and a Double J stent placement. However, no cases of renal atrophy, kidney failure, severe hematuria, or severe infections were recorded in the long-term follow-up.

4. DISCUSSION

We conducted the study on 92 patients (60 males, 32 females) with a mean age of 52 ± 11.76 years (range: 19 - 70 years), all of whom had unilateral or bilateral kidney stones. The mean stone length was 25.7 ± 5.9 mm.

PCNL through a mini-tunnel offers many advantages, but there are certain drawbacks due to the smaller size of the access tunnel. The smaller working space makes it more difficult to manipulate and handle larger stones, presenting a challenge. There is no current consensus on the appropriate size of stones for mini-PCNL. In our study, 34 cases had stones ≥ 25 mm, which are considered difficult for mini-tunnel PCNL.

With a 79.3% stone-free rate immediately post-surgery and a 90.2% stone-free rate after one month, our study shows very promising results. The average surgical time was 71.86 ± 15.09 minutes (range: 45 - 112), which is within the recommended time of under 90 minutes for PCNL. Despite the relatively high proportion of stones ≥ 25 mm in our study, the stone-free rate is still commendable. The effectiveness of mini-PCNL has been a topic of great interest among authors. With smaller tunnel sizes, the surgeon faces limitations in observation space, which makes fragment removal more difficult. However, mini-PCNL generally results in less bleeding, which makes it easier to perform the surgery. We usually proactively fragment the stones, starting at positions where the fragments can move into spaces that improve visibility during lithotripsy. The fragments are washed out through the ureteral catheter and aspirated via the Amplatz sheath, contributing to a high stone-free rate.

Given the small tunnel size, stones need to be fragmented, and the surgical time should be kept as short as possible due to potential risks (e.g., infection, bleeding). Thus, selecting patients with appropriately sized stones is crucial. According to previous studies on mini-PCNL, the stone-free rates after surgery were reported as 96.5% by Hennessey[4], 85.47% by Do et al.[5], 86.2% by Hoang et al.[6] and 72.7% by Luong.[7]

Theoretically, renal injury from mini-PCNL is less compared to standard PCNL, as it involves less bleeding and reduced postoperative pain. In our study, the overall complication rate, based on the Clavien classification, was 12%. Grade 1 complications: 5 cases of fever requiring a change in antibiotics; 2 cases of Double J stent failure to descend into the bladder (1 patient had urine leakage through the drainage site and fever); after re-inserting the Double J stent, the patients stabilized. Grade 2 complications: 3 cases of bleeding during and after surgery; 2 cases of intraoperative bleeding (2.2%) requiring cessation of stone fragmentation. Both cases stabilized after blood transfusion. 1 case of postoperative bleeding requiring selective angiographic embolization (1.1%), classified as grade 3. We did not observe any cases of nephrostomy tube displacement, injury to adjacent organs, conversion to open surgery, or Grade 4 or 5 complications according to the Clavien classification. For comparison, Özgör et al.'s study on 360 patients with renal calyceal stones found a complication rate of 18.05%[8], while Hoang et al. reported a complication rate of 10%.[6]

V. CONCLUSION

The initial findings from the study conducted on 92 patients with kidney stones who underwent mini-PCNL at Can Gio Medical Center in Ho Chi Minh City show very encouraging results. The stone-free rate achieved was notably high, with 79.2% of patients being completely stone-free immediately after surgery and an impressive 90.2% remaining stone-free after one month of follow-up. Additionally, the complication rate was relatively low, standing at only 12%, and importantly, there were no reports of severe complications. The duration of both the surgical procedure and the postoperative treatment was within expected ranges, aligning closely with the findings from other domestic studies in this field. These promising outcomes highlight the effectiveness and safety of mini-PCNL as a treatment option for kidney stone patients.

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