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The Safety and Efficiency of Percutaneous Nephrolithotomy in Managing Renal Stones in A Single Solitary Kidney

Faqed Faraj Almusawi [1]

[1] Department of Urology, Al-Nassiriyah Teaching Hospital, Al-Nassiriyah, Iraq.

Abstract

Background: Urologists have significant challenges when treating individuals with a solitary functional kidney who have renal stones. Various therapeutic approaches are employed to treat renal stones in people with just one working kidney, such as shock wave lithotripsy, retrograde intrarenal surgery, and percutaneous nephrolithotomy (PCNL).

Objective: To assess the safety and efficiency of PCNL in patients with a solitary kidney.

Patients and Methods: A percutaneous nephrolithotomy (PCNL) procedure was conducted on 20 patients who had a solitary kidney and were experiencing renal stone issues. The upper calyceal route was utilized. Factors such as the duration of the operation, full removal of the stone, presence of any remaining stone fragments, decrease in hemoglobin levels, requirement for a blood transfusion, necessity for any follow-up procedures, and length of hospital stay were all taken into account. Patients were monitored for a period of 6 months after the surgical procedure to identify any potential problems.

Results: The mean age of the patients was 45.45±7.49 years (range: 34–61 years). About two-thirds of the patients (65%) were male. The mean stone size was 3.81 ± 1.57 cm. The mean operative time was 53.3±15.57 min (range: 30-90 min). Secondary puncture was required only in one case (5%). Residual stones were reported in 3 patients. Four patients (20%) needed blood transfusions. The mean duration of hospital stay was 36.3±16.51 hrs. Serum creatinine had dropped from 2.2±0.88 mg/dL preoperation to 1.54±0.31 mg/dL after 6 months postoperation, with a significant difference.

Conclusion: PCNL is a safe and effective method for the removal of renal stones in patients with a solitary kidney, especially when other management options are not feasible. The procedure is associated with acceptable rate of residual stone, blood transfusion and postoperative hospital stay.

Keywords: Solitary functional kidney, percutaneous nephrolithotomy, renal stone.

Correspondence: Faqed Faraj Almusawi
Email: Dr_faqedfaraj@yahoo.com

Website: https://djm.uodiyala.edu.iq/index.php/djm

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Introduction

Large renal calculi pose a significant risk to those who have just one functioning kidney. These factors can potentially result in urinary tract infection (UTI), anuria, renal insufficiency, or sepsis, which can have severe consequences for patients with impaired kidney function (1,2). Consequently, patients with a single kidney require proactive treatment for stones. Managing stones in these individuals continues to be a difficult situation, where completely removing the stone and

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safeguarding renal function through safe surgical therapies is crucial (1,3).

The treatment options available for such renal stones range from medical dissolution therapy through extracorporeal shockwave lithotripsy (ESWL) and open surgery to minimally invasive surgery like percutaneous nephrolithotomy (PCNL). Advances in the ESWL and PCNL over the past several decades have not only revolutionized the treatment of renal stones but also has facilitated the ease with which stones are removed (4). Of note, ESWL is largely depend on the number of sessions an failure at initial treatment is associated with a low success rate for subsequent ESWL (5). Percutaneous nephrolithotomy (PCNL) is a viable choice for treating intricate kidney stones, even in individuals with just one functioning kidney (6). The PCNL was first introduced in 1976 (7). Since then, PCNL has become a commonly used method for renal calculi, especially in cases with staghorn stones or cases in which stones are larger than 2 cm. Currently, endoscopic procedures have advanced significantly, making PCNL a viable choice for complicated kidney stones, even in patients with single kidneys (8), although it was found to be associated with readmission by some authors (9). Despite the technical approach being identical to that of patients with bilateral healthy kidneys, surgery on a single kidney is more difficult due to the danger of problems during and after the procedure, which could lead to the lone renal unit deteriorating. As a result, when performing PCNL on single kidney patients, the surgeon experiences heightened anxiety (10).

Solitary kidney results from various causes, mainly including congenital factors and iatrogenic factors. The prevalence of kidney stones is 8.8% (11), and patients with a solitary functioning kidney are also at a high risk of developing kidney stones; an untreated staghorn stone is likely to destroy the kidney and cause life-threatening sepsis (12). A solitary kidney would compensate for hypertrophy, and its cortex would incrassate, which makes it vulnerable. From this aspect, management of stones in a solitary kidney is intractable for urologists. Despite its potential surgical complications, including infection, severe bleeding and urinary fistula, PCNL providing reasonable SFRs while preserving renal function (13). In order to minimize such deterioration and ensure effective stone clearance, it is imperative to perform the surgical approach with great precision in these patients. Research in the literature indicates that PCNL procedures conducted on kidneys that are working alone have been linked to a higher rate of complications compared to kidneys that are functional on both sides (14). Those with greater thickness of the renal parenchyma due to compensatory hypertrophy are more susceptible to hemorrhage during PCNL treatment compared to those with bilateral kidneys (15). Furthermore, the presence of substantial bleeding in these individuals can lead to the development of acute renal failure. This occurs when blood clots clog the urinary system and the remaining kidney is unable to compensate for the loss of renal function (16). Based on these findings, it seems reasonable to take care of the question of whether the PCNL procedure is safe and effective in aging male patients with a solitary kidney.

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The aim of this study is to evaluate the safety and efficacy of percutaneous nephrolithotomy (PCNL) in individuals who have only one functioning kidney. Given that the majority of data on this topic is derived from the Western population, to the best of my understanding, this study represents the first attempt to investigate this intricate phenomenon in Iraq.

Patients and Methods

This is a prospective descriptive study conducted at a single center. The study included 20 consecutive patients who had a single kidney and were diagnosed with renal stones. These patients were scheduled for percutaneous nephrolithotomy (PCNL) at Al-Nasiriyah Teaching Hospital between 1st of January and 31st of December 2022. The study included patients with pelvic calculus and/or inferior calyceal calculi. However, the study excluded patients who had calyceal diverticula stones, a history of coagulopathy, those who were morbidly obese, and those with congenital UT defects. The study received approval from the local committee of Al-Nasiriyah Teaching Hospital. Following a comprehensive evaluation of the patient's medical history and physical examination, all individuals received a series of diagnostic procedures, including renal ultrasonography, X-ray KUB, non-contrast computed tomography (NCCT), and several blood tests (renal function tests, electrolytes, and blood coagulation). Additionally, urine analysis as well as urine culture were performed. The study was endorsed by the local health committee, and every patient provided their written informed consent.

Surgical Technique

The identical cohort of urologists conducted percutaneous nephrolithotomies (PCNL) on all patients while they were under sedation. The initial procedures involve performing a cystoscopy and inserting a 6Fr ureteral catheter to see the renal collecting system using contrast material.

Patients received treatment using upper calyceal approaches, which were conducted within the space amid the paraspinal and posterior axillary line. The puncture of the upper calyceal supracostal was consistently carried out in the mid-scapular line, namely in the eleventh intercostal gap. The puncture site was located to the lateral side of the mid-scapular line in patients who were fat. The skin and under-skin punctures were conducted throughout the exhalation phase of supracostal punctures, while profound inhalation was employed for punctures in renal parenchyma. The unobstructed flow of urine via the needle and the accurate placement of the Teremo guidewire were used as criteria to determine a fruitful calyceal puncture. The Alken metal dilator device was employed to expand the original tract to a diameter of 24 French units (Fr), followed by the introduction of an amplatz sheath. The stones were fragmented using a Swiss Lithoclast Master, manufactured by Electro Medical Systems in Nyon, Switzerland, along with a rigid nephroscope made by Stortz with a size of 24-26Fr. After the process of breaking the stones into smaller pieces and removing them, direct nephroscopy and fluoroscopy were employed to examine the collecting system for any leftover stones. Both nephrostomy implantation and antegrade Double-J stenting are performed in all cases. During the postoperative phase, patients' chest pain, difficulty breathing, rapid breathing, and limited air entry were thoroughly observed. If

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deemed required, intercostal drainage was planned in response to potential thoracic problems. On the first day after surgery, the patients' hemoglobin levels were tested, and a KUB X-ray was conducted.

Factors such as the length of the operation, complete removal of the stone, remaining stone fragments, decrease in hemoglobin levels, requirement for a blood transfusion, necessity for additional procedures, and duration of hospital stay were all taken into account. Full clearance was defined as the complete absence of a visible shadow on the X-ray KUB taken after the surgery or a remaining stone size of less than 4 mm as determined by US/CT. A blood transfusion is administered if the hemoglobin level during surgery drops below 8 g/dL. Patients were monitored for a duration of one month following the surgery, during which any complications that occurred after the operation were documented.

Statistical Analysis

The data was tabulated and analyzed using the SPSS version 25 computer program, which is a statistical package for social science. Descriptive analysis was performed for numerical data using the mean and standard deviation, whereas for categorical data, they were calculated using frequency and distribution. The study employed a paired t-test to assess the levels of serum creatinine before and 6 months after the procedure. A p-value of 0.05 was deemed statistically significant.

Results

Preoperative characteristics of the patients: The mean age of the patients was 45.45±7.49 years (range: 34–61 years). About two-thirds of the patients (65%) were male, with a male-to-female ratio of 1.86:1. The left-side kidney was more frequent, accounting for 60% of the patients. The mean stone size was 3.81±1.57 cm (range: 1.5–7.0 cm). The mean serum level of creatinine before operation was 2.2±0.88 mg/dL (range: 1.14–4.4 mg/dL), as shown in Table 1.

Table (1): Preoperative characteristics of the patients.

Variables	Value
Age, years	
Mean±SD	45.45±7.49
Range	34-61
Sex	
Male	13(65%)
Female	7(35%)
Affected side	
Right	8(40%)
Left	12(60%)
Stone size, cm	
Mean±SD	3.81±1.57
Range	1.5-7.0
Preoperative Cr, mg/dL	
Mean±SD	2.2±0.88
Range	1.1-4.0

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Intraoperative characteristics of the patients:
Intraoperative characteristics of the patients are shown in table 2. The mean operative time was 53.3±15.57 min (range: 30-90 min). The vast majority of patients (95%) did not required secondary puncture; however 5% of the patients required such intervention. Residual stones were reported in 3 patients (15%) (2 of whom had 5 mm and the third one had 10 mm residual stone). Four patients (20%) needed blood transfusion (one unit in three patients and 2 units in one patient) as shown in Table 2.

Table (2): Intraoperative characteristics of the patients.

Variables	Value
Operative time, min	
Mean±SD	53.3±15.57
Range	30-90
Secondary puncture required	
No	19(95%)
Yes	1(5%)
Residual stone	
No	17(85%)
Yes	3(15%)
Blood transfusion	
No	16(80%)
Yes	4(20%)

Postoperative characteristics
The mean duration of hospital stay was 36.3±16.51 hrs (range: 16-72 hrs). After six months postoperative, the mean serum creatinine was 1.54±0.31 mg/dL (range=1.0-2.1), as shown in Table 3.

Table 3: postoperative characteristics.

Variables	Value
Hospital stay, hrs	
Mean±SD	36.3±16.51
Range	16-72
Postop serum Cr, mg/dL	
Mean±SD	1.54±0.31
Range	1.0-2.1

Comparison of creatinine before and after surgery
Paired t-test was used to compare serum creatinine level before and six months after surgery. As depicted in figure 1, serum creatinine declined from 2.2±0.88 mg/dl to 1.54±0.71 mg/dl. Statistically, there was a highly significant difference between the two readings.

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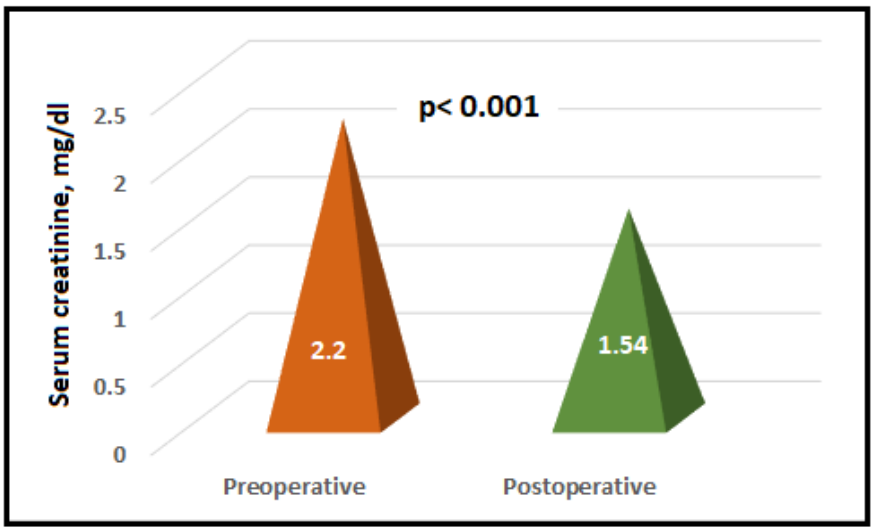

Figure (1): The mean serum level of creatinine in patients with solitary kidney before undergoing PCNL and 6 months after surgery.

Discussion

Currently, the surgical treatment of kidney stones has undergone significant transformation due to remarkable advancements in endoscopic technology. Patients with a solitary kidney are at a higher risk of perioperative problems and renal function impairment after surgery (15). In the current era of minimally invasive surgery, PCNL is a primary surgical method used to remove large renal stones (16). This study included 20 patients with single, solitary kidneys aged 45.45±7.49 years, of whom 65% were males. In China, a study conducted by Bai *et al*. (17) found 73.3% out of 116 consecutive patients with solitary kidneys were males, and the mean age of the patients was 52.22 ± 10.56 years. A very recent study assessed 47 patients; out of them, 32 (68.09%) were males. The mean age was 39.89 ± 15.33 years (18). Another study from the UK conducted by Jones et al. (19) on a total of 116 patients (69 males) with a mean age of 49.6 years The above-mentioned articles share some similarities, like middle age and male predominance. Our investigation revealed that the duration of the operation varied between 30 and 90 minutes, with an average operative time of 53.3±15.57 minutes. A research group from India (20) demonstrated that the operative time varied between 40 and 300 minutes, with an average operative time of 85.1 minutes. According to a study conducted by Jones et al (19), the average duration of a surgical procedure called URS for treating kidney stones in a single kidney was found to be 64.9 minutes, with a range of 18 to 190 minutes. Another study from Brazil conducted by Torricelli et al (21) showed that the mean operative time was 138.3±36.7 minutes. In a study conducted on 16 Turkish patients by Besiroglu et al (10), the total operative time was 85.3 (52–109) minutes. The superiority of the present study over the above-mentioned studies is that the shorter operative time may be due to the experience of the surgical team. In the current study, only one patient (5%) required a second puncture. In their study,

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Torricelli et al (21) from Brazil reported that 25% of their PCNLs were done with two percutaneous accesses. In another study from Pakistan, only two patients (4.26%) required multiple tracts (18).

The study found that the stone-free percentage was 85% which is within the context of international studies. In Torricelli et al.'s study, the rate of patients without stones was 67%. (21), Jones et al. (19) documented the safety of PCNL in patients with a solitary kidney, demonstrating a stone-free rate of 77.3% (defined as the absence of any remaining calculi or pieces measuring ≤2 mm). According to a study conducted in India on 128 patients, the rate of successfully removing kidney stones following the first PCNL procedure was 88.1% in group 1 and 50% in group 2, as determined by the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (NKF K/DOQI) (22).

Four individuals (20%) in the current research required blood transfusions. According to a report, the requirement for blood transfusion and the likelihood of experiencing serious bleeding were greater following PCNL in solitary kidneys compared to bilateral kidneys (8). In the study conducted by Jones et al. (19), it was shown that 30.6% of the patients who had PCNL experienced postoperative problems. Among these issues, 5.6% of the patients required a blood transfusion. Hosseini and colleagues (23) conducted PCNL on a cohort of 412 individuals who had a single functioning kidney. Out of these patients, 19 (4.6%) experienced bleeding that necessitated a blood transfusion. Besiroglu et al. (10) found that 18% of the patients in their study, specifically 3 out of 16 patients, experienced hemorrhage that required transfusion during the perioperative period.

Compensatory hypertrophy frequently occurs in solitary kidneys, resulting in an increase in the thickness of the renal parenchyma. There was speculation that accessing such dense renal tissue could potentially raise the danger of bleeding. Some risk factors for significant bleeding include puncturing the upper calix, having a large stone, having many tracts, being operated on by an untrained surgeon, and having just one kidney (14).

The current study found that hospital stays varied from 16 to 72 hours, with an average duration of 36.3±16.51 hours. Torricelli *et al* (21) discovered that the mean length of hospital stay was 5.6±3.9 (ranging from 2 to 16) days. Approximately 55.5% of patients had a hospital stay of little more than 4 days. Only a total of four patients required hospitalization for a duration exceeding one week as a result of surgical complications. Besiroglu et al (10) reported that the hospital stay lasted for an average of 4.7 days, ranging from 3 to 8 days.

Our study detected significant improvement in renal function as measured by the serum level of creatinine, which was 2.2±0.88 (1.1–4.0 mg/dL) preoperatively and 1.54±0.31 (1.0–2.1 mg/dL) postoperatively. Similar to our study, a Turkish study showed that serum creatinine levels were 1.38 (0.7–2.6) preoperatively and 1.20 (0.7–2.2) postoperatively (8). We may speculate that purifying the kidney from the stones leads to improved kidney function.

Mithani et al (18) conducted a study to evaluate the renal function of patients with a solitary kidney before and after undergoing PCNL. The researchers discovered that the average serum creatinine level at the

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beginning of the study was 2.45 mg/dL, but it fell to 2.32 mg/dL after the surgery. Upon additional observation, the patients exhibited an average serum creatinine level of 1.97 mg/dL, which represented a drop of 0.48 mg/dL from the initial measurement.

Conclusions

Overall, our data suggest that percutaneous nephrolithotomy (PCNL) is a secure and efficient technique for patients who have just one functioning kidney. Nevertheless, it is imperative to validate our discoveries through additional well-planned investigations, which should involve a more extensive group of participants.

Recommendations

The study recommends using PCNL as a gold standard for the treatment of renal stones in patients with solitary kidneys when there are no specific contraindications.

Source of Funding: The current study was funded by our charges with no any other funding sources elsewhere.

Ethical Clearance: Official approval has been obtained to use data and data were analyzed without the names to protect privacy. This study was conducted according to the approval of College of Medicine/ University of Diyala and in accordance with the ethical guidelines of the Declaration of ethical committee of the College (Document no. 2024FFM864).

Conflict of Interest: Non

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سلامة وكفاءة عملية استئصال حصوات الكلى عن طريق الجلد في علاج حصوات الكلى في الكلية المنفردة

فاقد فرج الموسوي [١]

الملخص

خلفية الدراسة: يواجه أطباء المسالك البولية تحديات كبيرة عند علاج الأفراد الذين يعانون من الكلية الانفرادية والذين لديهم حصوات كلوية. يتم استخدام أساليب علاجية مختلفة لعلاج حصوات الكلى لدى الأشخاص الذين لديهم كلية انفرادية، مثل تفتيت الحصى بموجة الصدمة، والجراحة الرجعية داخل الكلى، واستئصال حصوات الكلى عن طريق الجلد

اهداف الدراسة: تقييم سلامة وكفاءة واستئصال حصوات الكلى عن طريق الجلد في المرضى الذين يعانون من الكلى الانفرادية.

المرضى والطرائق: تم إجراء عملية استئصال حصوات الكلى عن طريق الجل على ٢٠ مريضًا لديهم كلية انفرادية وكانوا يعانون من مشاكل حصوات الكلى. استخدم الطريق الكاليسيلي العلوي لهذا الغرض. سجلت البايات ذات الصلة مثل مدة العملية، والإزالة الكاملة للحصوة، ووجود أي شظايا حصوة متبقية، وانخفاض مستويات الهيموجلوبين، والحاجة إلى نقل الدم، وضرورة أي إجراءات متابعة، ومدة الإقامة في المستشفى.. تمت متابعة المرضى لمدة ٦ أشهر بعد العملية الجراحية لتحديد أي مشاكل محتملة.

النتائج: بلغ متوسط عمر المرضى ٤٥,٤٥ ± ٧,٤٩ سنة (المدى: ٣٤-٦١ سنة). حوالي ثلثي المرضى (٦٥٪) كانوا من الذكور. كان متوسط حجم الحصوة ٣,٨١ ± ١,٥٧ سم، ومتوسط مدة العملية ٥٣,٣ ± ١٥,٥٧ دقيقة (المدى: ٣٠-٩٠ دقيقة). لوحظت الحاجة الى اجرا ثقب ثانوي حالة واحدة فقط (٥٪)، كما تم العثور على بقايا الحصوة في ٣ مرضى (١٥٪). أربعة مرضى (٢٠٪) احتاجوا إلى عمليات نقل دم. وكان متوسط مدة الإقامة في المستشفى ٣٦,٣ ± ١٦,٥١ ساعة. انخفض الكرياتينين في الدم من ٢,٢ ± ٠,٨٨ ملغم / ديسيلتر قبل العملية إلى ١,٥٤ ± ٠,٣١ ملغم / ديسيلتر بعد ٦ أشهر بعد العملية، وبفرق معنوي.

الاستنتاجات: استئصال حصوات الكلى عن طريق الجلد هو وسيلة آمنة وفعالة لإزالة حصوات الكلى لدى المرضى الذين يعانون من كلية منفردة، لاسيما عندما تكون خيارات العلاج الأخرى غير ممكنة.

الكلمات المفتاحية: كلية عاملة منفردة, استخراج حصوات الكلى عن طريق الجلد, حصوات الكلى.

البريد الالكتروني: Dr_faqedfaraj@yahoo.com

تاريخ استلام البحث: ٢٦ حزيران ٢٠٢٤

تاريخ قبول البحث: ٢٧ اب ٢٠٢٤

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[١] قسم الجراحة البولية/ مستشفى الناصرية التعليمي/ الناصرية/ العراق.