Original
ISSN 2521-8492

Renal Function Evaluation after Percutaneous Nephrolithotomy in Patients with Solitary Kidney

Hewa Khalid Abdullah*, Pishtewan Hashim Al Bazzaz

Rizgary Teaching Hospital, Erbil, Iraq.
*Correspondence to: Hewa Khalid Abdullah (E-mail: doctorhewa@yahoo.com)
(Submitted: 19 January 2021 – Revised version received: 10 February 2021 – Accepted: 21 March 2021 – Published online: 26 June 2021)

Abstract
Objective To evaluate renal function change after percutaneous nephrolithotomy in patients with solitary kidney.
Methods A prospective study conducted in the urology department at Rizgary Teaching Hospital for a period of 15 months from first of June 2018 until the end of August 2019. It included nine adult patients, all of them with solitary kidney and undergone percutaneous nephrolithotomy for management of renal calculi. Patients were considered to have a solitary kidney in case of congenital abnormality, contralateral nephrectomy, or solitary functioning kidney with contralateral atrophy (relative function < 10%). All patients were received prophylactic antibiotics (Ceftriaxone) at induction of anesthesia. All percutaneous nephrolithotomy procedures performed under general anesthesia in the prone position. Serum creatinine and creatinine clearance before the operation, at day one and day 21 postoperatively, operation time, duration of hospitalization, and postoperative complications recorded.
Results In this study, Means of serum creatinine at 1 day and 21 days postoperatively were significantly decreased compared to preoperative s. creatinine level Mean of creatinine clearance significantly increased after 21 days postoperatively compared to preoperative test, while no significant change in creatinine clearance after one day postoperatively.
Conclusion Generally, percutaneous nephrolithotomy considered as a safe and effective option for treatment of renal stones in solitary kidney patients considering the overall rate of complications and minimal morbidity. Moreover, significant renal function improvement anticipated in the early postoperative period.
Keywords Percutaneous nephrolithotomy, solitary kidney, renal function

Introduction

Renal stones are a common cause of hematuria and pain in the abdomen, flank, or groin. They occur in one in 11 people at some time in their lifetimes with men affected 2 to 1 over women. Stone formation is related to decreased urine volume or increased excretion of stone-forming components such as calcium, oxalate, uric acid, cystine, xanthine, and phosphate.[1] They occur when solutes crystallize out of urine to form stones. They may occur due to anatomic features leading to urinary stasis, low urine volume, dietary factors (e.g., high oxalate or high sodium), urinary tract infections, systemic acidosis, medications, or uncommonly genetic factors such as cystinuria. The most common cause of the stone disease is inadequate hydration and subsequent low urine volume.[2] Overall, urinary stone prevalence in the United States has increased from 3.8% in 1970 to 8.8% in 2010. For patients who have a history of a previous urinary stone, recurrence rates approach 50% at ten years.[3] Before the development of modern urologic techniques for treatment, mortality from untreated staghorn calculi was 27%. Currently, mortality from stone disease is rare, although there is still a significant rate (28%) of renal deterioration with certain stone types, particularly staghorn stones.[3,4] Many stones may managed conservatively in an outpatient. Smaller stones (less than 5 mm) have a greater chance (90%) of passing on their own with medical therapy. A urinary tract infection should be treated with antibiotics.[5] Electively, stones can be surgically managed in several ways, like (Extracorporeal shockwave lithotripsy (ESWL), Ureteroscopy (URS) and percutaneous nephrolithotomy [PCNL]). For large (greater than 2 cm) stones, percutaneous nephrolithotomy can be performed.[6] Percutaneous nephrolithotomy is the preferred treatment of choice for renal calculi. It has evolved remarkably since the eighties. The indications have changed over the years with the introduction of others techniques such as ESWL and flexible ureteroscopy.[7] PCNL is a mini-invasive procedure. It is safe due to the small number of complications and patient-friendly as the patient does not spend much time in hospital.[8] Patients with a functionally or anatomically solitary kidney require carefully planned surgery in order to optimize the chance for recovery after one effective surgical procedure and minimize the risk of complications, in case of nephrolithiasis in the solitary kidney, an operator has to think of the safest method to remove concernments so that the risk of re-surgery can be diminished and the patient can be protected from organ loss.[9] Aim of study: to evaluate renal function change after percutaneous nephrolithotomy in patients with solitary kidney.

Method

This study included nine patients, all of them with solitary kidney and undergone percutaneous nephrolithotomy for management of renal calculi. Patients were considered to have a solitary kidney in case of congenital abnormality, contralateral nephrectomy, or solitary functioning kidney with contralateral atrophy (relative function < 10%).[10]

Exclusion Criteria

Patients treated with mini-PCN, Contraindicated for PCNL.

The selected patients evaluated preoperatively by recording the following data:

- ✓ Demographic data as age, and gender.
- ✓ Comorbidities (Hypertension and diabetes).
- ✓ Site, size, number, and opacity of stones.
- ✓ Presence of hydronephrosis.

- ✓ Cause of solitary kidney (Congenital or Acquired).
- ✓ Serum creatinine, creatinine clearance.
- ✓ Body Mass Index (BMI):[11] Is calculated by weight in (kilograms) divided by the square of height in (meters). The same scale measures weight and height for all the subjects.
  BMI = Weight (Kg) / Square height (m^2)
  Participants classified according to BMI as:
  Normal (≤ 24.99 kg/m^2)
  Overweight (25–29.99 kg/m^2)
  Obese (≥ 30 kg/m^2)

The surgeries done in the Urology Department of Rizgary Teaching Hospital. All patients were received prophylactic antibiotics (Ceftriaxone) at induction of anesthesia. All PCNLs performed under general anesthesia in the prone position. At the beginning of surgery, the patient was positioned in dorsal lithotomy position and retrograde access was done by putting 5-Fr open-ended ureteral catheter by semi-rigid ureteroscope, and then 16 Fr. Urethral catheter inserted into the bladder and the balloon was inflated with 10 cc diluted contrast to localize bladder neck during DJ insertion at the end of the surgery. Then ureteral catheter tied to Foley's catheter to prevent stent migration during repositioning of the patient. Then the position of patient changed to prone with good support of the chest and pelvic area using proper size towel coils.

Surgical Site Preparation

After skin preparation with Iodine then contrast injected through the ureteral catheter to opacify the pelvicalyceal system then access to the pelvicaliceal system was performed under fluoroscopy guidance (using multidirectional C-arm fluoroscopic guidance) into the posterior calix using 18 gauge Storz needle. A successful puncture indicated by either free flow of clear fluid from the needle or anti-grade contrast injection to opacity of the pelvi-calyceal system. Dilatation was done with Alken coaxial telescopic dilators (Karl Storz Endoskope, Germany) up to 30 Fr. A rigid nephroscope of 28 Fr. (Karl Storz Endoskope) was passed through an Amplatz sheath (Boston Scientific Corp., Natick, MA, USA). The number of tracts created depended on the stone burden, and pelvicaliceal system anatomy. Pneumatic lithotripsy (Swiss Lithoclast, EMS, Nyon, Switzerland) and/or various stone forceps or graspers were used in all cases. The operations completed when significant and/or complete stone bulk cleared and/or when major complications occurred. At the end of the surgery, Double-J stent and 18 Fr nephrostomy placed in all cases.

The operation time counted from induction of anesthesia to the insertion of nephrostomy.

Postoperative at day 1, nearly all cases, the nephrostomy tube removed and after few hours later the urethral Foley's catheter removed, and the patients discharged at day 2.

Usually after three weeks, the patient scheduled for DJ stent removal and assessment of patient for any residual stone done by CT-KUB. Stones of any size considered as residual stone.

Intra and postoperative data recorded including the following:

- ✓ Position of PCNL.
- ✓ Operation time (defined from the induction of anesthesia until the end of nephrostomy tube placement).
- ✓ Number of urinary tracts.
- ✓ Blood transfused or not.
- ✓ Serum creatinine and creatinine clearance at day one and day 21 postoperatively.
- ✓ Duration of hospitalization.
- ✓ Postoperative complications (Hematuria, or fever). The data analyzed using Statistical Package for Social Sciences (SPSS) version 25. The data presented as mean, standard deviation and ranges. Categorical data presented by frequencies and percentages. Paired *t*-test was used to compare the hemoglobin, serum creatinine, and creatinine clearance on pre and postoperatively. A level of *P* – value less than 0.05 considered significant.

Results

The total number of study patients was nine. All of them diagnosed with solitary kidney and underwent percutaneous nephrolithotomy for management of renal calculi (PCNL). The distribution of study patients by general characteristics shown in Figures 1 and 2 and Table 1. Study patient's age was ranging from 23 to 56 years with a mean of 34.22 years and standard deviation (SD) of ±10.05 years. The highest proportion of study patients was aged ≥30 years (55.6%). Regarding gender, proportion of males was higher than females (66.7% versus 33.3%) with a male to female ratio of 2:1. Concerning BMI level, four patients were overweighed (44.4%) and four patients were obese (44.4%).

The distribution of study patients by clinical information shown in Table 2. In this study, 55.6% of patients diagnosed with moderate hydronephrosis and the most common cause of solitary kidney was congenital cause (77.8%). Stone in two thirds of patients (66.7%) involved the right kidney.

About comorbidities, the proportion of patients with hypertension are (44.4%).

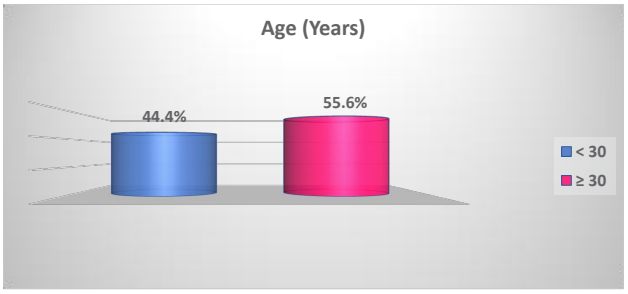

Fig. 1 **Distribution of study patients by age.**

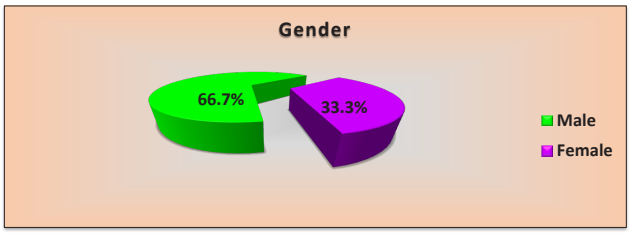

Fig. 2 **Distribution of study patients by gender.**

Table 1. **Distribution of study patients by BMI level**

BMI level	No. (*n* = 9)	Percentage (%)
Normal	1	11.2
Overweight	4	44.4
Obese	4	44.4

The distribution of study patients by stone information shown in Table 3. Study patient's stone size was ranging from 13 to 28 mm with a mean of 18.88 mm and standard deviation (SD) of ±5.08 mm. Regarding stone number, most of study patients diagnosed with one stone (88.9%).

Concerning stone size, 55.6% of cases were stone size <2 cm.

The distribution of study patients by intra and postoperative data shown in Table 4. In this study, during PCNL, one tract used in 88.9% of cases and the most of them had did not complained from hypotension during operation (88.9%). Regarding blood transfusion, 88.9% of study patients did not need blood transfusion and postoperative fever noticed in 33.3% of patients. Operation time was ranging from 40 to 130 min with a mean of 76.44 min and standard deviation (SD) of ±29.7 min. Concerning duration of hospitalization, it was ranging from 1.5 to 6 days with a mean of 2.77 day and SD of ±1.46 day. Postoperative hematuria per Foley's catheter noticed in all patients and all of them operated in prone position.

The comparison in mean of serum creatinine pre and postoperatively is shown in Table 5. Means of serum creatinine at 1 day and 21 days postoperatively were significantly decreased compared to preoperative s. creatinine level (1.67 versus 2.07 gm/dl, P = 0.02; and 0.91 versus 2.07 gm/dl, P = 0.002 respectively).

The comparison in mean of creatinine clearance pre and postoperatively is shown in Table 6. Mean of creatinine clearance was significantly increased after 21 days postoperatively compared to preoperative test (81.68 versus 43.62 ml/min, P = 0.001), while no significant change (P = 0.056) in creatinine clearance after one day postoperatively.

Table 2. **Distribution of case group by clinical information**

Clinical information	No. (n = 9)	Percentage (%)
Hydronephrosis		
Mild	4	44.4
Moderate	5	55.6
Cause of solitary kidney		
Congenital	7	77.8
Acquired	2	22.2
Laterality		
Right	6	66.7
Left	3	33.3
Comorbidities		
DM	1	11.1
Hypertension	4	44.4
Renal insufficiency	1	11.1
No comorbidities	3	33.1

Table 3. **Distribution of case group by stone information**

Stone information	No. (n = 9)	Percentage (%)
Stone number		
One	8	88.9
Two	1	11.1
Stone size		
<2 cm	5	55.6
2 cm or more	4	44.4

Table 4. **Distribution of study patients by intra and postoperative data**

Variable	No. (n = 9)	Percentage (%)
Number of tracts used		
1	8	88.9
2	1	11.1
Intraoperative hypotension		
Yes	1	11.1
No	8	88.9
Blood transfusion		
No	8	88.9
Yes	1	11.1
Postoperative fever		
Yes	3	33.3
No	6	66.7
Stone free rate		
Stone free	7	77.8
4 mm	1	11.1
5 mm	1	11.1

Table 5. **Comparison in mean of serum creatinine pre and postoperatively**

Variable	Serum creatinine (mg/dl) Mean ± SD	P-value
Preoperatively	2.07 ± 0.75	0.02
1 day postoperatively	1.67 ± 0.6	
Preoperatively	2.07 ± 0.75	0.002
21 days postoperatively	0.91 ± 0.35	

Table 6. **Comparison in mean of creatinine clearance pre and postoperatively**

Variable	Creatinine clearance (ml/mint) Mean ± SD	P-value
Preoperatively	43.62 ± 20.08	0.056
1 day postoperatively	73.44 ± 37.04	
Preoperatively	43.62 ± 20.08	0.001
21 days postoperatively	81.68 ± 25.37	

Discussion

Nowadays, the surgical management of renal stones dramatically changed because of tremendous reformation in endoscopy technology. As increased risk of perioperative complications and impairment of renal function for patients with solitary kidney during surgical management,[12] thus,

which surgical approach use continues to be of significant concern. In the era of minimally invasive surgery, PCNL and Retrograde intra-renal surgeries (RIRS) are major surgical techniques for removing large renal stones.[13]

In the current study, means of s. creatinine at 1 day and 21 days postoperatively were significantly decreased compared to preoperative s. creatinine level ($P = 0.02$ and $P = 0.002$ respectively). A comparable results observed in a study conducted by Resorlu and colleagues in 2011, as noticed that mean and SD of serum creatinine was significantly decreased after one-month duration after PCNL ($P = 0.05$).[14] Furthermore, Fabio and colleagues in their study at 2015 found a slight Creatinine readings variation in preoperative and postoperative period, as the preoperative reading was 1.5 mg/dl that dropped to 1.3 mg/dl in the postoperative period.[15] An untreated calculus is likely to destroy the kidney and cause life-threatening sepsis, which manifested as impaired renal function. Complete removal of the stone is, therefore, crucial in order to eradicate any causative organisms, relieve obstruction, and prevent further stone growth the most deleterious effect on renal function is neglected obstruction. If obstruction is rapidly relieved the kidney will regain basal function.[16]

In the present study, Creatinine clearance using CKD-EPI formula used, mean of creatinine clearance was significantly increased after 21 days postoperatively compared to preoperative test ($P = 0.001$), while no significant change ($P = 0.056$) in creatinine clearance after one day postoperatively. Similarly, Canes and colleagues in their study in 2009, retrospectively assessed the impact of PCNL on the renal function of 81 patients with a solitary kidney. The authors indicated that renal function was preserved, and even slightly improved, and that a statistically significant improvement in GFR occurred during the postoperative year.[17] In a study conducted by Fabio and colleagues in 2015, a Creatinine Clearance variation observed between intraoperative and postoperative period, in which an improvement in creatinine clearance observed, as the Initial preoperative reading was 60.5 mL/min and the final result in postoperative period was 60 mL/min.[15] The results of Wong et al study in 2013 are consistent with this finding and most cases involved in the study were associated with an improvement or stabilization in renal function in the form of improved estimated glomerular filtration rate (eGFR), Chronic Kidney Disease Epidemiology Collaboration Formula (CKD-EPI) is used. They found that eGFR was stable or improved at three months after PCNL in all cases. Serum creatinine values improved from 144 to 126 umol/L before and after the procedure and mean eGFR improved similarly from 51 to 59 ml/mint, respectively.[18]

In this study, one tract was used during PCNL in 88.9% of cases and 88.9% of them had no hypotension during operation, 88.9% of study patients didn't need blood transfusion and postoperative fever was noticed in 33.7% of patients. Bia and colleagues in their study in 2017 agreed to the current one in that only 11.7% of patients need transfusion, while differed in that only 11.7% had fever.[19] Different results observed in Resorlu et al. study in 2011, in which PCNL used in treating 16 patients with staghorn stones in a solitary kidney to determine long-term renal functional results. They noticed that Postoperative fever developed in three patients (18.8%) and the same percentage required blood transfusion.[14]

Operation time in this study was ranging from 40 to 130 min with a mean and SD of 76.44 ± 29.7 min. Postoperative hematuria occurred in all patients. In comparison to other studies, a comparable results observed in a study conducted by Bai and colleagues in 2017, as found that mean and SD of operation time in patient underwent PCNL was 78.75 ± 27.0 minutes and ranging from 42 to 141minutes.[19] A shorter duration of PCNL observed in a study conducted by Akman and colleagues in their study that conducted in 2011, in which noticed that mean operative time was 65.12 ± 22.83 minutes (range: 30–130 minutes).[20] In other study, a longer duration of PCNL observed in a study conducted by Resorlu and colleagues in 2011, as noticed that mean of operative time was 95.2 minutes, ranging from 55–145 minutes.[14]

Conclusion

Generally, percutaneous nephrolithotomy considered as a safe and effective option for treatment of renal stones in solitary kidney patients considering the overall rate of complications and minimal morbidity. Moreover, significant renal function improvement anticipated in the early postoperative period.

References

1. Reesink DJ, Scheltema J, Barendrecht M, Boeken Kruger A, Jansonius A, Wiltink J, et al. Extracorporeal shock wave lithotripsy under intravenous sedation for treatment of urolithiasis. Scandinavian Journal of Urology. 2018;52(5-6):453-8.
2. Bowen DK, Tasian GE. Pediatric stone disease. Urologic Clinics. 2018;45(4):539-50.
3. Jobs K, Rakowska M, Paturej A. Urolithiasis in the pediatric population-current opinion on epidemiology, patophysiology, diagnostic evaluation and treatment. Developmental Period Medicine. 2018;22(2):201-8.
4. Bauza J, Pieras E, Grases F, Tubau V, Guimerà J, Sabaté X, et al. Urinary tract infections etiopathogenic role in nephrolithiasis formation. Medical Hypotheses. 2018; 118:34-5.
5. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nature Reviews Urology. 2016;13(11):654.
6. Wiener SV, Ho SP, Stoller ML. Beginnings of nephrolithiasis: insights into the past, present and future of Randall's plaque formation research. Current Opinion in Nephrology and Hypertension. 2018;27(4):236-42.
7. Ganpule AP, Vijayakumar M, Malpani A, Desai MR. Percutaneous nephrolithotomy (PCNL) a critical review. International Journal of Surgery. 2016;36:660-4.
8. Rastinehad AR, Andonian S, Smith AD, Siegel DN. Management of hemorrhagic complications associated with percutaneous nephrolithotomy. Journal of Endourology. 2009;23(10):1763-7.
9. Kupajski M, Tkocz M, Ziaja D. Modern management of stone disease in patients with a solitary kidney. Videosurgery and Other Miniinvasive Techniques. 2012;7(1):1.
10. Campbell MF, Wein AJ, Kavoussi LR. Campbell-Walsh urology: editor-in-chief, Alan J. Wein; editors, Louis R. Kavoussi...[et al.]. Urology: WB Saunders; 2007.
11. World Health Organization. Body Mass Index. 2018.
12. Giusti G, Proietti S, Cindolo L, Peschechera R, Sortino G, Berardinelli F, et al. Is retrograde intrarenal surgery a viable treatment option for renal stones in patients with solitary kidney? World Journal of Urology. 2015;33(3):309-14.
13. Türk C, Petřík A, Sarica K, Seitz C, Skolarikos A, Straub M, et al. EAU Guidelines on Interventional Treatment for Urolithiasis. European Urology. 2016;69(3):475-82.
14. Resorlu B, Kara C, Oguz U, Bayindir M, Unsal A. Percutaneous nephrolithotomy for complex caliceal and staghorn stones in patients with solitary kidney. Urological Research. 2011;39(3):171-6.

15. Fabio C. GPP, Giovanni S. Marchini, Fabio C. et al. Percutaneous nephrolithotomy in patients with solitary kidney: a critical outcome analysis. Int Braz J Urol. 2015; 41:((3)):496-502.
16. Desai M GA. Management of the staghorn calculus: multiple-tract versus single-tract percutaneous nephrolithotomy. Curr Opin Urol. 2008; 18:220-3.
17. Canes D, Hegarty NJ, Kamoi K, Haber G-P, Berger A, Aron M, et al. Functional Outcomes Following Percutaneous Surgery in the Solitary Kidney. The Journal of Urology. 2009;181(1):154-60.
18. Wong KA, Sahai, A., Patel, A., Thomas, K., Bultitude, M., Glass, J. Is Percutaneous Nephrolithotomy in Solitary Kidneys Safe? Urology,. 2013; 82((5),):1013-6.
19. Bai Y, Wang X, Yang Y, Han P, Wang J. Percutaneous nephrolithotomy versus retrograde intrarenal surgery for the treatment of kidney stones up to 2 cm in patients with solitary kidney: a single centre experience. BMC Urology. 2017;17(1):9.
20. Akman T, Binbay M, Tekinarslan E, Ozkuvanci U, Kezer C, Erbin A, et al. Outcomes of percutaneous nephrolithotomy in patients with solitary kidneys: a single-center experience. Urology. 2011;78(2):272-6.