UIJ UroToday International Journal®

Percutaneous Nephrolithotomy in Solitary Kidneys with or without Renal Failure: Does Nadir Serum Creatinine Predict Long-Term Renal Function?

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Submitted August 2, 2012 - Accepted for Publication October 3, 2012

ABSTRACT

Aim: To present our experience of performing percutaneous nephrolithotomy (PNL) in solitary kidneys with or without renal failure, and assessing the postoperative complications and importance of nadir serum creatinine as marker of long-term renal function.

Material and Methods: In a retrospective study, the records of 28 patients with solitary functioning kidney (N = 12) or congenital solitary kidney (N = 16) underwent PNL between January 2004 to July 2012 were analyzed. Mild renal failure (creatinine: 1.6 to 3.0 mg %) was present in 4 patients and moderate renal failure (creatinine: 3.1 to 6.0 mg %) was present in 8 patients. Internal ureteral stenting was performed in renal failure cases, except in 4 patients who required percutaneous nephrostomy and had moderate renal failure with infected hydronephrosis. Diabetes mellitus and/or hypertension were present in 9 patients. Complete stone clearance was achieved in all except 2 cases, which had clinically significant residue (CSR) of 8 mm. Both these required shock-wave lithotripsy (SWL) and they were stone free at 4 weeks. The patients were followed up with serum creatinine and a renal ultrasound.

Results: Gross hematuria requiring blood transfusion was observed in 4 patients. All these patients initially presented with moderate renal failure, infected hydronephrosis, diabetes mellitus, and hypertension. The median follow-up was 42.5 months. The nadir serum creatinine followed internal stenting or nephrostomy if it remained above the baseline; it failed to touch the normal level following PNL.

Conclusion: PNL in solitary functioning or congenitally solitary kidneys is a safe and effective procedure. The bleeding is the commonest complication, and it can be managed conservatively. The nadir serum creatinine remains the most important predictor of long-term renal function.

INTRODUCTION

Percutaneous nephrolithotomy (PNL) is the procedure of choice for kidney stones more than 3 cm, staghorn stones, complex renal stones, stones with renal failure, recurrent renal stones, and in failed cases of extracorporeal shock-wave lithotripsy [1,2]. Stones in solitary kidneys could be life threatening to patients if they progress to renal failure or are complicated by infection [3-5]. The associated comorbidities such as diabetes mellitus and hypertension further compromise renal function [6-8]. Bleeding is a major concern in PNL, with the average hemoglobin drop ranging from 2.1 gm/dl to 3.3 gm/dl [6,9,10]. As a result, 1 to 11% of patients overall and 2 to 53% of those who underwent PNL for staghorn stones require blood transfusions [9-12]. Most of the bleeding can be managed conservatively but it may require super-selective angioembolization in 0.8% of patients. Rarely nephrectomy can be required to save lives [5,10,13]. The presence of either anatomical or functioning solitary kidney with stones requires great caution and planning to avoid major bleeding. Solitary kidneys with compensatory

KEYWORDS: Percutaneous nephrolithotomy, solitary kidney, predictor of renal function

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CITATION: *UroToday Int J*. 2012 December;5(6):art 60. http://dx.doi.org/10.3834/uij.1944-5784.2012.12.05

hypertrophy predispose to major bleeding [2,5,9,13]. Recently, new techniques such as staged minimally invasive PNL with flexible retrograde ureteroscopy have emerged as management therapy for renal stones in solitary kidneys, even in renal failure patients, but it requires great expertise and experience, and the procedures are expensive [14].

In the present study, we retrospectively reviewed the record and assessed the outcome of PNL in solitary kidneys with respect to stone clearance, bleeding requiring transfusion, and renal functions in long-term follow-up.

MATERIALS AND METHODS

In a retrospective study from January 2004 to July 2012, records of 28 patients with solitary kidneys with stones managed by PNL were analyzed. The commonest clinical presentation of the patients was recurrent flank pain followed by hematuria, fever, and dysuria. A tender renal lump was present in 4 cases presenting with infected hydronephrosis. The complete hemogram; renal function test; liver function test; blood sugar test; renal and bladder ultrasound; plain X-ray of the kidney, ureter, and bladder (KUB) and coagulation profile; urinalysis; and a urine culture and sensitivity were done in all cases. An intravenous urogram (IVU) was obtained in cases with normal renal function. In cases with raised serum creatinine, a plain CT scan of the abdomen or an MR urogram was done. The patients with raised serum creatinine with hydronephrosis were subjected to cystoscopy and internal ureteral stenting to relieve the obstruction and preserve renal function. In cases of infected hydronephrosis, a percutaneous nephrostomy tube was inserted. A chest X-ray, electrocardiogram, and pulmonary function tests were done to determine whether patients were fit for anesthesia. Written and informed consent was taken prior to procedures. All patients were subjected to PNL after 2 weeks of either internal ureteral stents or percutaneous nephrostomy.

Under general anesthesia, cystoscopy and ureteric catheterization were performed with a Foley balloon catheter inserted in the bladder. The patient was placed in the prone position with bolsters under the chest. The pelvicalyceal system was opacified with diluted contrast and air injected to locate the most appropriate posterior or superior calyx to puncture. An 18-gauge puncture needle was used for punctures, and the subsequent dilatation of the tract was performed with Alken metallic dilators to 28 Fr. A 26 Fr (Richard Wolf) nephroscope was used for the procedure. A pneumatic lithoclast (Swiss Lithoclast) was used to fragment the stone and fragments were retrieved. For complete clearance or maximal clearance, another puncture was made to irrigate the calyx (intracaliceal puncture and irrigation). The puncture tract was dilated to retrieve the stones in 4 cases. A 6 Fr/26 cm ureteral stent and a 16 Fr nephrostomy catheter were inserted at the end of the procedure. In patients had 2 punctures and dilatations, and 2 nephrostomy catheters were inserted. Postoperatively, a chest X-ray was obtained in cases with supracostal punctures. A hemogram was obtained in the postoperative period in cases with significant hematuria with or without hemodynamic instability. If the hemoglobin level was less than 8 g/dl, a packed red cell was transfused to achieve the hemoglobin level of > 10 g/dl.

On the first or second postoperative day, a plain X-ray KUB and renal ultrasound were obtained to see the residual stones and position of the stent. Renal ultrasound was also used to see the status of perinephric collection and hematoma. Nephrostomy tubes were removed once there was complete cessation of hematuria. Postoperative serum creatinine and urine cultures were obtained in all cases. Patients were discharged and advised to remove stents after 2 weeks. The clinically significant residual stones (N = 2) more than 8 mm were taken for SWL (Dornier Compact Alpha). Stents were removed 2 to 4 weeks following SWL depending upon clearance of the fragments. Patients followed-up 3 to 6 times, monthly, with serum creatinine and renal ultrasounds. A 24-hour urine examination was done for total protein, albumin, creatinine, serum calcium, and uric acid estimation. Hypertensive patients had their blood pressure controlled by single or multiple antihypertensives containing angiotensin converting enzyme inhibitors. Diabetes control was maintained with endocrinologist consultations with a combination of plain and mixed insulin. The nephrologist was also consulted for raised serum creatinine, and applicable patients were put on standard treatments for chronic renal failure.

RESULTS

The mean patient age was 38 years (range: 24 to 52) with a male-to-female ratio of 16:12. The mean stone size was 3.4 cm (Table 1). Renal failure was present in 12 patients. Mild renal failure (creatinine: 1.5 to 3.0 mg %) was present in 4 patients, and moderate renal failure (creatinine: 3.1 to 6.0 mg %) was present in 8 patients (Table 1). Internal ureteral stenting was performed in 8 patients and percutaneous nephrostomy in 4 patients. In patients with serum creatinine below 3.0 mg %, the renal function became normal 2 weeks following stenting, but in those with serum creatinine > 3.1 mg %, creatinine showed a downward trend but failed to touch the baseline after 2 weeks of stenting/PCN (Table 3). In 4 patients, PCN was done for the infected hydronephrosis, and the pus culture showed E. coli. All 4 patients were hypertensive and diabetic.

The mean operating time was 90 minutes (70 to 120 minutes). The superior caliceal supracostal puncture was done in 14 patients, middle caliceal supracostal puncture in 10 patients (including 4 PCN tract dilatations), and inferior caliceal infracostal puncture in 4 patients. Superior caliceal punctures and dilatation were additionally required in 4 patients in

Table 1. The demographic characteristics of the patients.

Parameters	Value/No of Patients and Range
total number of patients	23
mean age in years	38 (range: 24-52)
sex ratio (male:female)	18:10
mean stone size (in cm)	3.4 (range: 2.5-6.5)
number of patients with normal serum creatinine (up to 1.5 mg %)	16
mild renal failure (serum creatinine: 1.6-3 mg %)	4
moderate renal failure (serum creatinine: 3.1-6)	8
mean serum calcium in mg %	9.2 (range: 8.8-10.2)
mean serum uric acid in mg %	5 (range: 4.8-7)
congenitally solitary kidney	16
functioning solitary kidney	12
unilateral nonfunctioning kidney with stone	6
unilateral small atrophic kidney	6
simple stone	18
complex stone	10
infected hydronephrosis	4
diabetes mellitus	4
hypertension	9

Table 2. The intraoperative and postoperative parameters.

Parameters	Value	Range/Remarks
superior calyceal supracostal puncture and dilation	14	in 4 initial PCN patients, another superior caliceal puncture and dilation was done for stone removal
middle calyceal supracostal puncture and dilation	10	including 4 PCN patients, which were dilated
inferior calyceal infracostal puncture and dilation	4	
mean operating time	90 minutes	(70-120 minutes)
mean fluroscopic time	5 minutes	(3-7 minutes)
mean irrigation volume (glycine: 1.5 %/normal saline /water in liters)	10 liters	(8-12)
mean hemoglobin drop (in gm %)	2.8 ± 1.1 gm %	1.8-3.4 gm %
no of patients who underwent SWL for CSR (8 mm)	2	complete clearance at 4 weeks

which initial PCN was done for infected hydronephrosis (Table 2). Single-stage PNL was performed in all cases. The mean fluoroscopic time was 5 minutes (range: 3 to 7 minutes), and the mean irrigation (1.5% glycine/Normal saline/water) volume used was 10 liters (8 to 12 liters). The mean fall in hemoglobin following PNL was 2.8 ± 1.1 gm % (range: 1.8 to 3.4 gm %). Complete stone clearance was achieved in all except 2 cases (CSR: 8 mm) for which SWL was done (Table 2). Finally, all patients were stone free at 4 weeks. The median follow-up was 42.5 months. In 4 patients, gross hematuria started intraoperatively and continued postoperatively for 24 hours, with initial hemodynamic instability. Hemoglobin was less than 8 gm % just following the procedure and required blood transfusion. The mean transfusion of packed red cells was 2.2 units (range: 2 to 3 units). Postoperatively, febrile urinary tract infections (N = 3) were treated with broad-spectrum antibiotics. None of the patients had hydrothorax, pneumothorax, or hemothorax following the procedure. The 24-hour urinary estimation for protein showed micro/macro albuminuria in patients that had persistently raised serum creatinine following PNL. The natural course and progress of the patients initially presenting with renal failure are shown in Table 3. Stone recurrence was seen in 2 patients who were managed with conservative treatment.

DISCUSSION

The stones in solitary kidneys can cause obstruction, which is a risk for renal damage, particularly if associated with infection [1-3]. Chronic kidney disease due to associated hypertension and diabetes mellitus also threatens renal function [4-7]. Renal function remains the most important concern in long-term follow-up, particularly in patients with solitary kidneys. The PNL in a solitary kidney can produce serious consequences that can complicate the procedure. Bleeding is the most significant complication of PNL and this becomes extremely important if the procedure is performed on solitary kidneys. The life-threatening

Table 3. The natural course and progression of renal failure in patients initially presenting with renal failure.

	Stone Character	DM	HTN	Inf HDN	BL Cret	Nadir Creat 2 Wks	Cret 3 M	Cret 6 M	Cret 12 M	Cret 24 M	Cret 36 M	Cret Last FU	Last FU M
1	pelvic	-	-	-	2.8	1.2	1.3	1.2	1.1	1.3	1.2	1.2	90
2	partial stag	-	+	-	2.4	1.1	1.2	1.1	1.2	1.2	1.3	1.3	55
3	pelvic with middle calyceal	-	-	-	2.2	1.1	1.3	1.3	1.4	1.4	1.4	1.5	50
4	pelvic with inferior calyceal	-	-	-	3	1.3	1.3	1.4	1.3	1.4	1.3	1.4	20
5	staghorn	+	+	+	6	3.1	2.5	3.4	3.2	3.8	3.9	4	75
6	staghorn	+	+	+	5.5	3.3	2	2.3	2.4	2.5	2.8	2.9	60
7	partial stag	-	+	-	3.7	2	2.1	2.2	2.8	2.9	3	3	59
8	pelvic with sup calyceal	+	+	+	4.3	3	3.2	3.4	4	3.8	3.9	4	52
9	pelvic	-	+	-	5	2.5	2.1	2.8	3.2	3.3	3.5	3.5	40
10	staghorn	+	+	+	4.8	2	1.9	2.2	2.3	2.2	2.3	2.4	38
11	partial stag	-	+	-	4.9	2.3	2.2	2.3	2.3	3	3.5	3.7	37
12	staghorn	-	+	-	4.5	2.8	3	4.2	4.6	5.2	6.3	6.5	12

DM: diabetes mellitus; HTN: hypertension; Inf HDN: infected hydronephrosis; BL Cret: baseline cretanine; Nadir Cret 2 Wks: nadir creatinine at 2 weeks; Cret 3 M: creatinine at 3 months; Cret 6 M: creatinine at 6 months; Cret 12 M: creatinine at 12 months; Cret 24 M: creatinine at 24 months; Cret 36 M: creatinine at 36 months; Cret Last FU: creatinine at last follow-up; Last FU M: last follow-up, in months

hemorrhage requires super-selective angioembolization and even nephrectomy may be required in settings where intervention radiology is not available [2-6]. Bleeding requiring transfusion rates have been reported between 0.8 and 45% in PNL series [1,2,4,6,7,]. Most of the bleeding can be managed with conservative measures, except in < 1% of cases requiring angioembolization [8-10]. The presence of diabetes mellitus, hypertension, intraoperative complications such as trauma to the urothelium and infundibular tear, multiple tracts, and prolonged operative time are the other risk factors [7,8,11-13]. Renal failure and infections might have a role in the excessive bleeding in PNL [6,7,13-17].

In a retrospective analysis of 3 878 PNL patients, El-Nihas et al. reported risk factors for extensive post-PNL bleeding. These are superior caliceal puncture, staghorn stones, multiple punctures, comparatively inexperienced surgeons, and the presence of a solitary kidney [19]. In our present study, the bleeding requiring transfusion was seen in 4 patients (18.2%) but none required angioembolization. All these 4 patients had staghorn stones, initial PCN for infected hydronephrosis, superior caliceal puncture and dilatation, diabetes mellitus, hypertension, and multiple (2) tracts for stone clearance. The tract size was 28 Fr in all patients. Making comparatively smaller tract sizes could have decreased the bleeding but again the operative time would have been longer, leading to more complications. The larger tract sizes allow for rapid removal of larger stone fragments and thus minimize operative time and intracalyceal irrigation and manipulations, which might contribute to bleeding, infection, and electrolyte imbalances [3,9,13,16,18].

Renal function remains a definite short-term or long-term outcome concern of PNL in anatomical or functional solitary kidneys. Resorlu et al. showed that patients who underwent PNL for a solitary kidney had a significant decrease in serum creatinine and an increase in estimated glomerular filtration rates (eGFR) after a period of 1 month, postoperatively [2]. Canes et al. retrospectively reviewed the effect of PNL on renal function in 81 patients that had solitary kidneys. They estimated the eGFR preoperatively and postoperatively, and they showed a mean increase in eGFR from 44.9 ml to 51.5 ml/min/1.73 m^2 1 year following PNL, which was statistically significantly. The other important observation of this study was that the eGFR could worsen following PNL, which was seen in 6.8% of patients [20]. Witherow and Wickham reported that mean creatinine clearances increased significantly after nephrolithotomy in patients with severely decreased renal function because of stone disease [21]. The CROES PCNL Global Study Group reported the largest series of PNL in 189 patients having solitary kidneys and has compared the procedure in patients with bilateral kidneys. It was interesting that the level of renal impairment was significantly higher, and stone-free rates were significantly lower following PNL with solitary kidneys in comparison to bilateral kidneys. Bleeding was equal in both groups but solitary kidney patients required significantly more transfusions [22]. Kuzgunbay et al., in an interesting paper, reported the PNL in patients with impaired renal function. With a mean follow-up of 51 months, they concluded that most of the patients presenting with renal stones with renal failure experience improvement or stabilization of renal function following PNL. Despite the relief of obstruction, if the patients have solitary kidneys, diabetes mellitus, or atherosclerosis there is a greater risk of renal function deterioration [23].

The potential effect of multiple tracts on renal function in solitary kidneys remains another concern. Handa et al. reported that a single PNL procedure in humans and animals produces a small but permanent parenchymal scar at the site of the nephrostomy tract after several weeks [24]. Associated interstitial inflammation and the local parenchymal injury by tract dilatation usually resolve but can progress to fibrosis and scarring involving large distances from the tract. It is also not clear whether punctured papilla can regain its normal function over time [20,25]. Multiple-tract PNL may magnify the loss of parenchymal tissue with resultant, diminished, global renal function, but the renal function has not been tested by well-planned, single-tract PNL versus multitract PNL [9,17,18,24,26]. Akman et al. have shown that renal function in the early and late postoperative periods were not significantly or clinically affected by the creation of multiple tracts. In their series, only 1 patient (1 out of 12) had multiple tract procedures that showed delayed deterioration in renal function [9].

The presence of chronic kidney disease due to diabetes mellitus and hypertension increase blood loss in PNL. The associated renal failure further complicates the problem [1,6,7,13,19,21]. The mechanism is associated with arteriosclerosis and thickened basement membranes, making such patients more prone to bleeding after initial trauma of tract formation. El-Nahas et al. reported that staghorn stones were a significant independent risk factor because during PNL for such complex stones multiple tracts and excessive manipulation were needed. They also identified that a solitary kidney was a significant risk factor for bleeding because compensatory hypertrophy is a normal physiological response as thickened renal parenchyma increases with increased kidney size [19]. It is speculated that punctures and dilatation through thick renal parenchyma may increase the possibility of damage to more renal tissue and its vascular supply, which could be the major cause of excessive bleeding [26-28].

In the present study, gross hematuria with initial hemodynamic instability requiring a blood transfusion was observed in 4 patients. All of these patients had large stone bulk with infected hydronephrosis for which they initially required percutaneous nephrostomy. They had diabetes, hypertension, and renal failure. The serum creatinine showed a downward trend following PCN but failed to reach the normal level. These patients required 2 punctures and dilatations for complete stone removal. The serum creatinine in long-term follow-up did not touch the baseline but remained consistently raised, and the patients were labeled as having established chronic renal failure. Renal failure was investigated and found to have associated diabetic nephropathy with albuminuria. Hypertension as an associated comorbidity was present in 5 patients, who also presented with renal failure. Of this, 1 patient had serum creatinine below 3 mg %, which reversed to normal levels following internal stenting. In the other 4 patients, renal failure was moderate (creatinine > 3.1 mg %), which on internal stenting showed a downward trend (raised nadir serum creatinine at 2 weeks) but the serum creatinine remained raised in follow-up consultations. Renal failure in such patients was labeled as hypertensive nephrosclerosis with albuminuria.

Stone clearance and recurrence are 2 very important aspects of PNL with solitary kidneys. Stone clearance in the present study was assessed by 3 methods. These were the intraoperative evaluation with a fluoroscope following Amplatz sheath removal, and both postoperative X-ray KUB and renal ultrasound. The ultrasound was done by a highly experienced sonologist dedicated to urology; therefore, the chances of overestimation or underestimation of stones was unlikely. While computerized tomography (CT) is used at many centers worldwide to assess stone clearance, it is associated with radiation exposure, and it is expensive compared to ultrasounds [29,30]. Stone recurrence was seen in 2 patients. Stone size ranged from 5 to 6 mm, which was managed conservatively using alkali therapy, and subsequent, follow-up ultrasounds did not show stones although there was no definite history of lithiuria.

CONCLUSION

PNL in solitary functioning or in congenital solitary kidneys is a safe and effective procedure. The presence of infection and associated comorbidities predispose patients to significant bleeding, requiring blood transfusions. Renal failure is multifactorial, which is due to obstruction, infection, and associated comorbidities. Nadir serum creatinine remains the most important predictor of long-term renal function

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UIJ / Vol 5 / Iss 6 / December / http://dx.doi.org/10.3834/uij.1944-5784.2012.12.05 *ISSN 1944-5792 (print), ISSN 1944-5784 (online)*