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ORIGINAL PAPER

Percutaneous nephrolithotomy in patients with normal versus impaired renal function

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Abstract This study aimed to compare the results of percutaneous nephrolithotomy (PCNL) in patients with impaired renal function (IRF) and normal renal function (NRF). Records of 300 consecutive patients who underwent PCNL from July 2002 to July 2005 were retrospectively reviewed. Nineteen patients (6.3%) had serum creatinine values higher than 1.5 mg/dl before surgery (IRF Group). Nineteen gender and age matched patients with normal renal function were chosen as controls (NRF Group). The surgical parameters, outcome, and complication rates were compared. The effect of PCNL on the renal function was assessed in patients with IRF. There were 13 male and 6 female patients in both groups. In the IRF group, seven patients had a solitary kidney and three had bilateral stones. Thus, PCNL was performed on 22 kidneys. No patients in the NRF Group had solitary kidney or bilateral stones and PCNL was performed on 19 kidneys. There were no statistically significant differences between the two groups for success and complication rates ($P = 0.376$ and $P = 0.184$, respectively). In a mean follow-up of 15.6 months, mean serum creatinine decreased from 2.8 to 2.6 mg/dl ($P = 0.273$) in patients of the IRF group. Similar stone clearance and complication rates were obtained with PCNL in patients with impaired and normal renal function. Surgery does not cause biochemical deterioration in patients with compromised renal function before treatment.

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Introduction

Patients with renal insufficiency comprise 0.78–17.5% of the cases treated for urinary stone disease [1–5]. These patients often have bulky stones. Gupta et al. [1] reported that 75.8% of urolithiasis patients with mild to moderate renal insufficiency required multiple procedures for treatment including extracorporeal shock wave lithotripsy (ESWL), percutaneous and ureteroscopic procedures and even open surgery. Patients with renal insufficiency frequently have various medical conditions such as diabetes, hypertension, anemia, and bleeding disorders, which have detrimental effects on their general health. Consequently, there may be concerns that these patients will suffer from lower success and higher complication rates compared to patients with normal renal function. Thus, compromised renal function may constitute a drawback to standard surgical treatment and cause bias in favor of more conservative measures. We analyzed the results of patients with impaired renal functions (IRF) who underwent percutaneous nephrolithotomy (PCNL) for the treatment of kidney stone disease and compared the surgical parameters and outcome with a matched control group with normal renal function (NRF). We also evaluated the effect of PCNL on serum creatinine values.

Patients and methods

Records of 300 consecutive patients who were treated with PCNL for kidney stone disease from July 2002 to

July 2005 were retrospectively reviewed. Patients with serum creatinine values above 1.5 mg/dl (normal 0.3–1.4 mg/dl) in at least two measurements within 4 weeks before surgery were considered in the IRF Group. The lowest creatinine value obtained before surgery was accepted as the baseline creatinine level of the patient. For patients with acute exacerbation of renal failure caused by urinary infection or obstruction, the lowest creatinine value obtained after the relief of obstruction and infection and stabilization of renal function was used. Thus, no patients with acute renal failure were included in the study group.

Nineteen patients out of 300 (6.3%) had serum creatinine values higher than 1.5 mg/dl (IRF Group). Of these, 13 were males and 6 were females. Nineteen gender and age-matched patients who were treated with PCNL for kidney stone disease during the same period and had normal serum creatinine values were chosen as controls (NRF Group). All of the operations were performed in a single center by any member of a team of four urologists. Surgical parameters, outcome, complication and adjuvant treatment rates were compared between the two groups. In the IRF Group, serum creatinine values before surgery and after follow-up were compared in order to assess the effect of PCNL on renal function.

Pre-operative management included decompression of the obstructed units, culture-specific antibiotic treatment of those with urinary tract infection and transfusions for those with severe anemia. Nephrology consultation was obtained for all patients with IRF for the control of hypertension as well as the planning of renal replacement therapy before and after surgery as necessary. Stone diameter was taken as the largest diameter of the stone measured in millimeters on a plain radiogram. Stones with a central body in the renal pelvis and at least one caliceal branch were defined as partial staghorn, and stones that fill the renal pelvis and all calyces were defined as complete staghorn calculi. A pneumatic lithotriptor was used for stone fragmentation. Operation time was derived from the anesthesia chart and defined as the time elapsed in minutes from the induction of anesthesia until the patient left the operating room. Hospitalization time was defined as the number of days the patient spent at the hospital starting from the day of surgery. A successful outcome was defined when the patients were rendered stone free or had residual fragments smaller than 4 mm after PCNL with or without adjuvant treatments. Patients who had residual fragments larger than 4 mm after PCNL with or without adjuvant treatments were regarded as failures.

Statistical analyses were done using the chi-square, independent and paired samples *t* tests.

Results

There were 13 male and 6 female patients in both groups. Mean age of patients in IRF and NRF Groups were 59 ± 16 and 58 ± 18 years, respectively ($P = 0.959$). In the IRF Group, seven patients had solitary kidneys and three patients had bilateral stones, thus PCNL was performed on 22 kidneys. No patient had simultaneous bilateral treatment. None of the patients in the NRF Group had solitary kidney or bilateral stones, thus PCNL was performed on 19 kidneys. In the IRF Group 12 of the 22 kidneys (55%) were stented (six double pigtail stents and six percutaneous nephrostomy tubes) for the relief of obstruction and/or infection before PCNL. Stenting was not necessary in any of the cases with normal renal function. As would be expected, the difference between the number of stented kidneys was significant between the two groups ($P < 0.01$). Urine cultures were positive for urinary infection in 6 (31.6%) and 2 (10.5%) patients in the IRF and NRF Groups, respectively ($P = 0.114$). The mean stone diameter appeared to be greater in the IRF Group (54 ± 20 mm) than that in the NRF Group (42 ± 24 mm), but this difference did not reach statistical significance ($P = 0.114$). In the IRF Group, 4 kidneys (18%) had complete and 13 kidneys (59%) had partial staghorn stones. In the NRF Group, two kidneys (10.5%) had complete and nine kidneys (47%) had partial staghorn stones. In the IRF Group there were ten calcium oxalate, four uric acid, two magnesium ammonium phosphate, two mixed uric acid and calcium oxalate, and one mixed calcium oxalate and phosphate stones. In the NRF Group there were 12 calcium oxalate, 2 uric acid, 2 mixed uric acid and calcium oxalate and, 1 magnesium ammonium phosphate stones. Stone composition was not available for two kidneys in the IRF and one kidney in the NRF groups.

Comparison of surgical parameters and outcome is shown in Table 1. Operation and nephrostomy removal times were comparable in the groups. Hospitalization time was 1 day longer in the IRF group, but the difference was not statistically significant. Although percutaneous access site above the 12th rib was used more frequently in the IRF Group, this difference remained insignificant. After PCNL, 7 of 22 kidneys were treated with adjunctive modalities in the IRF group, namely three extracorporeal shock wave lithotripsy (ESWL); one ESWL and ureteroscopy; one ESWL and chemolysis; one second-look PCNL; and one chemolysis. In the NRF Group, six kidneys were treated with adjunctive modalities noted as five ESWL; and one ESWL and cystolithotripsy. The success rate was higher in the NRF Group, but the difference was not statistically significant

Table 1 Surgical parameters and outcome of PCNL in IRF and NRF groups

	IRF Group (22 kidneys)	NRF Group (19 kidneys)	*P* value
Operation time (min)	175 ± 69	172 ± 61	0.897
Intercostal access (%)	13.6	5.3	0.368
Δ Hb (g/dl)	1.7 ± 1.1	1.5 ± 0.6	0.470
Nephrostomy time (days)	3.9 ± 1.8	3.4 ± 1.9	0.347
Hospitalization (days)	6.6 ± 5.6	5.4 ± 1.8	0.371
Success (%)	72.7	84.2	0.376
Adjunctive treatment (%)	31.8	31.6	0.987
Complications (%)	22.7	42.1	0.184

ΔHb: decrease in mean blood hemoglobin value after PCNL

(Table 1). Complications occurred in five cases during or after PCNL in the IRF Group and were noted as blood loss requiring transfusion in three cases; blood loss requiring transfusion and anuria due to ureteral obstruction caused by stone fragments in one case, and emergency admission because of colicky pain in one case. There were complications in eight cases in the NRF Group noted as blood loss requiring transfusion in four patients; fever in two; fever and urinary fistula from the percutaneous tract in one; and hemorrhage due to arteriovenous fistula formation in one. The seemingly higher complication rate in the NRF group did not reach statistical significance and most of the complications were minor. Significant blood loss that required transfusion during or after surgery occurred in four cases (18%) in the IRF Group and four cases (21%) in the NRF Group. In the IRF Group, mean blood hemoglobin level decreased from 12.2 ± 1 g/dl before PCNL to 10.7 ± 0.9 g/dl 12 h after surgery. In the NRF Group the corresponding hemoglobin values were 13.5 ± 1.3 and 11.8 ± 1.5 g/dl, respectively. There was no significant difference for the decrease in blood hemoglobin between the two groups (Table 1). The outcome was failure due to incomplete stone clearance in 6 of 22 kidneys in the IRF and 3 of 19 kidneys in the NRF Groups. Thus, the success rates in the two groups were comparable (Table 1).

The mean follow-up time was 15.6 months in the IRF Group. Mean serum creatinine value was 2.8 mg/dl before surgery and 2.6 mg/dl at the end of follow-up period. This slight decrease was not statistically significant ($P = 0.273$). In the IRF Group, seven patients had creatinine values less than 2 mg/dl. The mean creatinine value in these patients decreased from 1.69 mg/dl before PCNL to 1.57 mg/dl at the end of follow-up period. This decrease was also not significant ($P = 0.477$). However, serum creatinine values decreased to normal range in two patients in this group. Twelve patients had serum creatinine higher than 2 mg/dl before PCNL. The mean creatinine values before surgery, and at the end of follow-up period were 3.48 and 3.25 mg/dl, respectively. This difference was also not significant ($P = 0.383$). Two patients in this group were on hemodialysis before surgery. One patient who had been on hemodialysis for 4 months showed improvement of renal function and hemodialysis was discontinued after PCNL. However, another patient who was not on renal replacement therapy before PCNL, progressed to end-stage renal failure during the follow-up period. In the NRF Group, the mean serum creatinine levels before and 4 weeks after PCNL were 0.93 ± 0.16 and 0.94 ± 0.17 mg/dl, respectively ($P = 0.874$).

Discussion

The incidence of renal insufficiency in patients treated for urinary stone disease shows variations between centers and probably depends on the socioeconomic characteristics as well as the referral patterns of the region. Different centers reported 0.78–17.5% incidence of renal insufficiency in patients with urinary stone disease. These numbers usually come from retrospective analysis of stone patients treated in one facility and not from epidemiologic studies [1–5]. In the 300 consecutive patients who underwent PCNL at our institution, 19 patients (6.3%) had impaired renal function defined as serum creatinine level greater than 1.5 mg/dl.

Renal failure is frequently a progressive condition. The presence of stones in the urinary tract may accelerate the course of the disease. Presence of the stones deteriorates renal functions mainly by causing obstruction and infection [6]. The changes in the kidney parenchyma caused by infection are more pronounced if there is concomitant obstruction. Duration of the stone disease, multiple procedures, and stone recurrence also have negative influence on renal function [4]. Therefore, patients with compromised renal function benefit from the elimination of calculi from the urinary tract, which may lead to improved renal function and avoidance or postponement of dialysis. On the other hand, there is concern for the detrimental effect of surgical and endourological procedures on kidney function and the possibility of increased complications in patients with kidney failure. In the era before PCNL, Witherow and Wickham had reported that mean creatinine clearances increased significantly after nephrolithotomy in patients with severely decreased renal function due to stone disease [7]. After PCNL became a viable method of stone-treatment, laboratory and clinical studies showed that percutaneous procedures cause no significant

damage to functional nephrons [8–10]. As PCNL became the method of choice for patients with bulky stones, several authors reported the beneficial effect of PCNL on kidney function in patients with renal failure. Gupta et al. [1] treated 33 patients with serum creatinine levels of 2 mg/dl or greater at presentation. The patients underwent multiple procedures including PCNL, ESWL, ureteroscopic stone extraction, alkalinization and open surgery. In 32 of 33 patients post-treatment serum creatinine value was lower than the pretreatment value (mean 2 vs. 3.2 mg/dl, $P < 0.001$). Of the 13 patients with longer than 1-year follow-up, 4 had progression of intrinsic renal disease and elevation in serum creatinine level to greater than the pretreatment value. Three of these patients had subsequently end stage renal disease. Agrawal et al. [3] performed PCNL in 78 patients with calculus nephropathy and advanced uremia. Forty-six of these patients had bilateral upper urinary calculi and the remaining 32 had a solitary functioning kidney. Overall, the serum creatinine levels at the last follow-up showed a significant improvement over those before treatment. Sixty-four patients had improvement of renal function and in 11 patients renal function remained unchanged or deteriorated during follow-up. Kukreja et al. [2] analyzed data from 84 patients with baseline serum creatinine of >1.5 mg/dl treated for calculous disease. The mean baseline serum creatinine concentration was 2.87 mg/dl. Twelve patients had bilateral stone disease while another 12 patients had a solitary functioning kidney. Primary surgical treatment was PCNL for most of the patients but some underwent nephrolithotomy, and nephrectomy as well. Overall renal functions improved in 33 patients (39.3%), stabilized in 24 patients (28.6%), and deteriorated in 27 patients (32.2%). The baseline serum creatinine concentration correlated well with the postoperative renal function. Renal function stabilized or improved in nearly all patients with baseline serum creatinine less than 2 mg/dl and deteriorated in all patients with baseline serum creatinine higher than 6 mg/dl. All of five patients with creatinine higher than 6 mg/dl, progressed to end-stage renal disease. Goel et al. [11] reported on the role of intervention in 20 patients with a solitary kidney, nephrolithiasis and chronic renal insufficiency. In this group, 15 patients underwent PCNL, 2 ESWL and 3 open-surgery. The mean glomerular filtration rate improved significantly in renal failure patients after treatment of stone disease. Improvement in glomerular filtration rate was greater in mild to moderate renal failure. GFR deteriorated in one patient with baseline serum creatinine higher than 4 mg/dl. Patients with residual disease had longer mean hospital stay, more repeat anesthesia, blood transfusions and total cost. Chandhoke et al. [12] found no significant deterioration in renal function after PCNL in patients with moderate renal insufficiency. Jones et al. [13] reported on the results of PCNL on 14 patients with solitary kidney and abnormal renal function at presentation. After PCNL, serum creatinine increased in 2 and decreased in 12 patients. In our patients there was a slight but insignificant decrease in serum creatinine values at the end of the follow-up period. Serum creatinine values decreased to normal range in two of seven patients with a baseline serum creatinine less than 2 mg/dl. Creatinine values did not decrease to the normal range in any of the patients with a baseline creatinine level higher than 2 mg/dl. One of two patients on hemodialysis improved enough to come out of replacement therapy, but another patient deteriorated and was started on dialysis.

Evaluation of renal function by serum creatinine level has some disadvantages, especially in patients with two functioning kidneys. The deterioration in one kidney is compensated by the contralateral kidney. Thus, the change in serum creatinine does not accurately reflect the change in the function of the concerned kidney. Unfortunately, differential renal function and creatinine clearance measurements were not available for most of the patients in the IRF group. However, we feel that in the long-term follow-up, serum creatinine provides valid information on the overall renal function that reflects the effect of PCNL. Our results and the results of previous reports indicate that most patients presenting with kidney-stone disease and renal insufficiency, experience improvement or stabilization of renal function with early aggressive intervention aimed at complete stone clearance and prevention of urinary infection. Improvement in glomerular filtration rate is greater in mild to moderate renal failure. Patients with severe kidney-failure, reduced parenchymal thickness and pus in the collecting system are less likely to show a significant improvement in renal function. However, even these patients will enjoy the benefits of improved quality of life and postponement of replacement therapy if their stones and infection can be cleared [1–3, 11]. Therefore, the statement "one should temper obsessive attempts at clearance of small fragments with caution in the kidney with severely damaged function" is equally true for PCNL as it is for open-surgery [7, 13].

In addition to the effect of PCNL on kidney function, we also compared the surgical outcome between IRF and NRF groups. More patients in the IRF Group had urinary obstruction, infection, and staghorn stones. The mean stone diameter was higher in the IRF

Group. PCNL resulted in higher success rate in the NRF Group, but the difference was not significant. Adjuvant treatments were used in similar percent of kidneys between the two groups. Complications of PCNL are just as important as the success rate in patients with IRF. Many patients with renal insufficiency have anemia of chronic disease, platelet dysfunction, metabolic acidosis, and disturbances in serum electrolytes. Conditions such as diabetes and hypertension are also frequent. Therefore, any surgical intervention in these patients carries high morbidity and mortality rates. Agrawal et al. [3] reported 3.8% mortality and 17.3% morbidity rates for PCNL in 78 patients with advanced renal failure and no mortality and <1% morbidity in the 924 patients with normal renal function. The complications included septic shock, disseminated intravascular coagulation and hemorrhage, and death. Pre-operative and post-operative management is extremely important to reduce morbidity of PCNL. Patients should receive culture-specific antibiotics and infection should be cleared before any urinary tract manipulation whenever possible. In our study, the operative, indwelling nephrostomy and hospitalization times were similar between the two groups despite presence of more complex stones in the IRF Group. Most of the complications were minor and complication rates were not statistically different between the groups. Significant blood loss that required transfusion during or after surgery occurred in four cases (18%) in the IRF Group and four cases (21%) in the NRF Group. These results show that PCNL outcome and complication rates are not significantly different in patients with IRF compared to patients with NRF. Patients with chronic renal failure should be treated as patients with normal kidney function, provided that appropriate pre-operative preparations are performed.

In conclusion, we achieved similar stone clearance and complication rates with PCNL in patients with impaired and normal renal function. Supportive measures and availability of replacement therapy as necessary were essential factors in obtaining these favorable results. After PCNL, there was an overall decrease in serum creatinine values. These results show that stones in patients with elevated serum creatinine value should be treated as stones in patients with normal serum creatinine.

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