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ORIGINAL PAPER

Impacts of percutaneous nephrolithotomy on the estimated glomerular filtration rate during the first few days after surgery

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Abstract Long-term effects of percutaneous nephrolithotomy (PCNL) on renal function have been evaluated in many studies but there are little data on the renal effects of PCNL immediately after surgery in human patients. The aim of this study was to evaluate estimated glomerular filtration rate (GFR) during the first few days after PCNL. From July to September 2008, we gathered preoperative and postoperative serum creatinine data of all the patients who underwent PCNL at our center. Children and patients who received transfusion during surgery were excluded. Creatinine clearance was estimated by Cockcroft–Gault equation and was used to estimate GFR. 94 patients met the inclusion criteria. The mean ± SD of creatinine clearance by Cockcroft–Gault equation was 87.5 ± 32.2 cc/min before operation. It decreased to 85.5 ± 29.4 cc/min, 77.0 ± 26.8 cc/min and 75.9 ± 25.0 cc/min at 6, 24 and 48 h after operation and then increased slightly to 81.9 ± 26.4 cc/min 72 h after operation. Renal GFR decreases immediately after PCNL reaches a nadir 48 h after operation, and then, increases slowly. It seems advisable to avoid factors that can bear a negative influence on renal function during the early postoperative period such as nephrotoxic drugs, contrast agents, shock wave lithotripsy and Re-PCNL.

Keywords Percutaneous nephrolithotomy · Glomerular filtration rate · Renal function · Creatinine clearance

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Introduction

The impact of percutaneous nephrolithotomy (PCNL) on renal function has been evaluated in many studies. Many indicators have been used for this purpose such as serum creatinine [2, 3, 9, 14], DMSA scan [12, 13, 16], DTPA scan [7], ultrasonography [7] and MAG3 scan [4]. In most of these studies, the long-term effects of PCNL on renal function have been evaluated and no significant influence has been reported yet. There are limited data on the effects of PCNL on renal function immediately after surgery. Handa et al. [9] published an interesting article about the acute effects of percutaneous tract dilation on renal function and structure. He reported a dramatic decrease in glomerular filtration rate (GFR) during the first few hours after unilateral tract dilation in pigs. He also reported an increase in serum creatinine on the first postoperative day in human after PCNL operations. In another study, the acute effects of PCNL on renal function in geriatric patients were compared to the non-geriatric population and significant reduction in GFR was observed in both groups after PCNL [14]. We investigated serum creatinine serial measurements in the first few days after PCNL to assess for GFR changes.

Materials and methods

From July to September 2008, we gathered preoperative and postoperative serum creatinine of all patients who underwent PCNL at our center. Indications for PCNL were kidney stones >2 cm, stones refractory to shock wave lithotripsy (SWL), and large proximal ureteral stones. Patients older than or equal to 10 years old and normal contralateral kidney (on intravenous pyelography or CT scan) who did not receive transfusion during surgery were included in the study. The operation technique is summarized in the following. After general anesthesia, a 5 or 6 Fr ureteral catheter was inserted and fixed to a Foley catheter. The patient was then turned into a prone position with special care for the pressure points. The desired calyx was punctured under fluoroscopic guidance and a guide wire was inserted. Tract dilation was performed by amplatz dilators in a one-shot manner in most of the cases, and when impossible, dilation was performed by serial metallic dilators. After amplatz sheath insertion, nephroscopy was performed and stones were fragmented by a pneumatic lithotripter (Litho Crack, Sp. Swiss-Germany) and removed. Normal saline was used for continuous irrigation.

If there was a residual stone >2 cm that could not be accessed from the first tract, a second access was established. Residual stones of <2 cm in diameter were scheduled for SWL. No SWL was performed during first few days after surgery.

Foley and ureteral catheter were removed 24 h after operation. Nephrostomy tube was clamped 48 h after operation and removed after 24 h if there was no leak, pain, or fever available. Demographic and perioperative data such as age, sex, stone burden, laterality, co-morbid diseases, stone opacity, operation time, number and site of accesses and complications during and after surgery were recorded by the surgeon. Patients with excessive bleeding or hypotension during the operation and also patients with recent SWL were excluded from the study. Patients were kept hydrated during the operation and postoperative pain was controlled by narcotics. No non-steroidal anti-inflammatory drugs were used. Ceftriaxone was prescribed before operation and continued until discharge. Nephrotoxic drugs were not used before, during, or after the operation.

Preoperative serum creatinine and postoperative serum creatinine at 6, 24, 48 and 72 h after operation were collected from the hospital records of the patients who were not discharged. Creatinine clearance was calculated by Cockcroft–Gault [11] equation and was used to estimate GFR. Estimated blood loss (EBL) was calculated with the following equation: EBL = (Hct before op-Hct after op/Hct before op) $\times$ (weight $\times$ 85).

Data were analyzed by SPSS software version 16.0 (Chicago, IL). Paired t tests were used to compare postoperative creatinine clearances at 6, 24, 48 and 72 h with their preoperative values. Independent samples t test or one-way analysis of variance was used to compare for the magnitude of GFR reduction in the 24-h postoperative period relative to the preoperative GFR with independent variables. Two sided p values <0.05 were considered as statistically significant.

Results

Demographic and operation data are summarized in Table 1. From 105 PCNL operations during the study period, 94 patients met the inclusion criteria. The alterations of GFR before and after operation appear in Fig. 1. The mean $\pm$ SD of preoperative creatinine clearance was 87.5 $\pm$ 32.2 cc/min and decreased to 85.5 $\pm$ 29.4 cc/min 6 h after operation. Continuous decrease in GFR was observed up to 48 h after operation (75.9 $\pm$ 25.0 cc/min), and then, a slight increase was observed at 72 h after operation (81.9 $\pm$ 26.4 cc/min). The drops in GFR at 24 and 48 h after operation were statistically significant relative to their preoperative values ($p < 0.05$). Demographic data and operation variables such as age, weight, EBL, operation time, stone size and diabetes had no statistically significant associations with the magnitude of GFR changes 24 h after operation (p value > 0.05). The mean $\pm$ SD of the drop in creatinine clearance at 24, 48 and 72 h after operation in patients with one versus two accesses were 8.1 $\pm$ 24.4 versus 10.7 $\pm$ 8.8, 7.9 $\pm$ 19.0 versus 12.3 $\pm$ 10.8 and 2.6 $\pm$ 24.3 versus 10.2 $\pm$ 13.8. The drops in GFR of patients with two-access PCNL were higher than patients

Table 1 Demographic and perioperative data

Characteristics	
Sex (male/female)	60/34
Age, years	45 ± 14
Side (left/right)	57/37
Previous renal surgery	21 (22)
Greatest stone diameter	
<2 cm	5 (5)
2–5 cm	42 (45)
>5 cm	47 (50)
Number of accesses	
One	83 (88)
Two	11 (12)
Stone type	
Single	19 (20)
Staghorn	22 (23)
Multiple	53 (56)
Approach	
Subcostal	83 (88)
Intercostal/supracostal	4 (4)
Multiple	7 (7)
Estimated blood loss (ml)	292 ± 188
Operation duration (min)[a]	85 ± 22
Hospital stay (days)	3.3 ± 1.2

Data are presented as *N* (%), *N*/*N* or mean ± SD

[a] From intubation to nephrostomy fixation

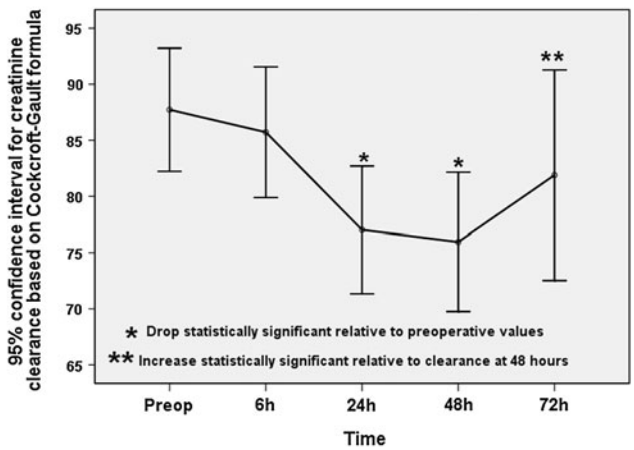

Fig. 1 Creatinine clearance based on Cockcroft–Gault equation before operation, also at 6, 24, 48 and 72 h after operation

with one access but these differences were not statistically significant (all $p > 0.05$). The percent of patients who encountered GFR reduction (>25%, 50% and 75%) at 24, 48 and 72 h after surgery is summarized in Table 2.

All minor pelvicaliceal system injuries were managed conservatively by keeping nephrostomy tube for a longer duration. No major complications (colon perforation, perinephric hematoma and sepsis) were observed in any patient.

As observed in Table 2, some patients did not have creatinine measurement at 24, 48 and 72 h after operation. The reason was that some patients were discharged 2 days after operation and for some patients creatinine measurement was not available in their files. We compared creatinine clearance values of these patients up to their last available measurement. No statistically significant difference was observed between patients with missed and available measurements. Also the magnitude of creatinine clearance change from preoperative values to all the available measurements before the missed one did not differ significantly between missed and available groups.

Discussion

An important goal of minimally invasive operations such as PCNL is less glomerular loss and scar formation. Many studies have supported the superiority of PCNL to open surgery regarding lower morbidity, shorter operative time, shorter hospital stay and earlier return to work. Experimental animal studies have revealed that scar formation after PCNL is less than one percent of renal parenchyma [5, 15, 17].

Indicators such as serum creatinine and renal isotope scans (DMSA, DTPA and MAG-3) have been used to assess kidney injury after PCNL and revealed no significant changes in renal function after operation [7, 12, 13, 16]. Chatham et al. [4] evaluated the impact of PCNL on differential renal function with 99mTc-MAG3 nuclear renography and serum creatinine measurements. The median time to the follow-up renal scans was 22 days (ranging from 7 to 461) postoperatively. They observed that renal function was preserved in 84% of patients. Serum creatinine was unchanged postoperatively. They finally concluded that PCNL does not result in loss of renal function when treating complex renal calculi as measured by nuclear scintigraphy. The effects of PCNL on renal function in high risk patients (children, old age, solitary kidney and chronic kidney disease) have been studied and long-term safety of this procedure has been shown [2, 3, 14, 16].

Dawaba et al. [7] studied the anatomical and functional effects of PCNL in children with DMSA and DTPA scan. The patients would be followed regularly every 3 months during first year, and every 6 months thereafter. At last, they concluded that the renal function improves without renal scarring. Nevertheless, the above studies evaluated long-term effects of PCNL on kidney function. Data regarding the early postoperative effects of PCNL on human kidney function are limited. Handa et al. [9] reported reduced GFR, renal plasma flow, and renal excretory function in female pigs up to 5 h after percutaneous tract dilation. In another part of his study, only the

Table 2 GFR and kidney injury categories in the studied patients during the first postoperative days

Characteristic	24 h, $N = 87$	48 h, $N = 64$	72 h, $N = 32$
Glomerular filtration rate cc/min, mean ± SD	77 ± 27	76 ± 25	82 ± 26
Percent reduction in preop GFR, median (IQR)	8 (−3, 23)	12 (−3, 20)	8 (−9, 22)
Patients with kidney risk, N (%)[a]	17 (20)	9 (14)	5 (16)
Patients with kidney injury, N (%)[b]	1 (1)	3 (5)	1 (3)
Patients with kidney failure, N (%)[c]	0 (0)	1 (2)	0 (0)

[a] Defined as >25% reduction in GFR or >1.5 times increase in serum creatinine

[b] Defined as >50% reduction in GFR or >2 times increase in serum creatinine

[c] Defined as >75% reduction in GFR or >3 times increase in serum creatinine

serum creatinine of human patients on the first postoperative day was gathered. He observed that mean serum creatinine was increased significantly, however; the duration and height of this increase were not reported.

Tok et al. [14] evaluated the effects of PCNL on renal function in geriatric patients with estimated GFR and it was compared to the non-geriatric population. Estimated GFR was recorded both preoperatively and postoperatively (12–24 h after the operation). Estimated GFR (ml/min) in geriatric group was 70.6 ± 23.0 preoperatively and 71.6 ± 22.3 postoperatively and in non-geriatric group 112.3 ± 36.3 preoperatively and 108.5 ± 36.1 postoperatively. They concluded that preoperative GFR had significant changes in the postoperative period.

We prospectively evaluated the effect of unilateral PCNL on GFR of patients with normal serum creatinine. The results showed an observable trend of GFR decrease up to 48 h after operation. Then, a slight increase in GFR was observed at 72 h after the operation. Longer follow up was not included in the data collection protocol as we did not have any prior idea about the exact time of GFR normalization. Handa et al. [10] have recently shown that in pigs, GFR decreases approximately 55% in operated kidneys and returns to preoperative values within 72 h. On the other hand, in a retrospective human study, they observed that serum creatinine decreases significantly at 1 and 2 days after PCNL but they did not follow their patients further [8]. Another human study reported that kidney function judged by radionuclide imaging returns to normal values 2 weeks after operation [17], Therefore, we think that the time of GFR normalization will possibly lie between 3 and 14 days after PCNL. Regarding the study data, we can assume that the return of GFR after PCNL starts between 48 and 72 h after operation. The results of this study are in accordance with the results of previous studies [9, 14] that reported GFR reduction in first postoperative day.

The magnitude of GFR reduction was not associated with demographic variables and operation characteristics such as age, weight, EBL, operation time, number of accesses, stone size. Handa et al. [8] have also shown previously that in animal models, single or multiple PCNL tracts did not change GFR by different magnitudes.

The magnitude of GFR reduction or creatinine rise in patients is illustrated in Table 2 with the categories defined for kidney risk, injury or failure [1]. Overall, 20 patients (23%) experienced kidney risk during postoperative days, 5 patients (6%) experienced kidney injury and 1 patient (1%) experienced kidney failure.

In this study, no nephrotoxic drug was used either preoperatively or postoperatively. Such medications can theoretically prolong the GFR reduction duration or the magnitude of its nadir. It is believed that a combination of factors such as tract dilation, nephroscopy and normal saline irrigation, also stone fragmentation with lithoclast are important in bilateral renal vasospasm and decreasing GFR in PCNL patients with normal contralateral kidney [9]. This is a preliminary study that raises other questions such as when the GFR returns to the normal value and what mediators are effective in decreasing GFR after PCNL and how to control them.

This study has some drawbacks: (1) the follow-up duration of the patients was limited to a few postoperative days. Longer follow up could reveal the time of GFR normalization. (2) Serum creatinine is not the best tool for GFR measurement. Cockcroft–Gault equation is a widely used formula and has the ability to show GFR changes with acceptable error [11]. As the goal of this study was to track GFR changes than to exactly measure it, we think that employing Cockcroft–Gault formula will not introduce significant error into the results [6]. (3) All patients did not have full measurements at 24, 48 and 72 h after operation. Although we showed that the creatinine clearance of these patients or the magnitude of its change up to the last documented measurement were not different between patients with missed and available measurements but we can not be sure that the available data are totally representative of the censored data. (4) Creatinine measurements were coincident with the time of urinary drainage manipulation like discontinuation of Foley, ureteral or nephrostomy catheters. We do not know whether these manipulations can influence the creatinine measurements we performed. Nevertheless, as discontinuation of Foley, ureteral and nephrostomy catheters after PCNL operation usually occurs at time schedules similar to what we performed, such influences, even if they exist, will also be observed for other operated patients as well.

Conclusions

The results of this series show that in the first 48 h after PCNL, renal GFR continually decreases and then rises toward preoperative values. It is advisable to avoid factors that can have a deleterious effect on kidney function during this early postoperative period such as nephrotoxic drugs, contrast agents, SWL and Re-PCNL.

Conflict of interest We, the authors of this manuscript have no conflict of interest.

References

1. Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P (2004) Acute renal failure: definition, outcome measures, animal models, fluid therapy and information technology needs. The second international consensus conference of the acute dialysis quality initiative (ADQI) group. Crit Care 8:R204–R212

2. Bilen CY, Inci K, Kocak B, Tan B, Sarikaya S, Sahin A (2008) Impact of percutaneous nephrolithotomy on estimated glomerular filtration rate in patients with chronic kidney disease. J Endourol 22:895–900
3. Chandhoke PS, Albala DM, Clayman RV (1992) Long-term comparison of renal function in patients with solitary kidneys and/or moderate renal insufficiency undergoing extracorporeal shock wave lithotripsy or percutaneous nephrolithotomy. J Urol 147:1226–1230
4. Chatham JR, Dykes TE, Kennon WG, Schwartz BF (2002) Effect of percutaneous nephrolithotomy on differential renal function as measured by mercaptoacetyl triglycine nuclear renography. Urology 59:522–525 (discussion 525–526)
5. clayman RV Ej, Miller RP (1987) Percutaneous nephrostomy: assessment of renal damage associated with semi-rigid (24F) and balloon (30F) dilation. J Urol 138:203
6. Coresh J, Toto RD, Kirk KA, Whelton PK, Massry S, Jones C, Agodoa L, Van Lente F (1998) Creatinine clearance as a measure of GFR in screenees for the African-American study of kidney disease and hypertension pilot study. Am J Kidney Dis 32:32–42
7. Dawaba MS, Shokeir AA, Hafez AT, Shoma AM, El-Sherbiny MT, Mokhtar A, Eraky I, El-Kenawy M, El-Kappany HA (2004) Percutaneous nephrolithotomy in children: early and late anatomical and functional results. J Urol 172:1078–1081
8. Handa RK, Evan AP, Willis LR, Johnson CD, Connors BA, Gao S, Lingeman JE, Matlaga BR, Miller NL, Handa SE (2009) Renal functional effects of multiple-tract percutaneous access. J Endourol 23:1951–1956
9. Handa RK, Matlaga BR, Connors BA, Ying J, Paterson RF, Kuo RL, Kim SC, Lingeman JE, Evan AP, Willis LR (2006) Acute effects of percutaneous tract dilation on renal function and structure. J Endourol 20:1030–1040
10. Handa RK, Willis LR, Connors BA, Gao S, Evan AP, Kim SC, Tinmouth WW, Lingeman JE (2010) Time-course for recovery of renal function after unilateral (single-tract) percutaneous access in the pig. J Endourol 24:283–288
11. Lin J, Knight EL, Hogan ML, Singh AK (2003) A comparison of prediction equations for estimating glomerular filtration rate in adults without kidney disease. J Am Soc Nephrol 14:2573–2580
12. Moskovitz B, Halachmi S, Sopov V, Burbara J, Horev N, Groshar D, Nativ O (2006) Effect of percutaneous nephrolithotripsy on renal function: assessment with quantitative SPECT of (99m)Tc-DMSA renal scintigraphy. J Endourol 20:102–106
13. Samad L, Qureshi S, Zaidi Z (2007) Does percutaneous nephrolithotomy in children cause significant renal scarring? J Pediatr Urol 3:36–39
14. Tok A, Ozturk S, Tepeler A, Tefekli AH, Kazancioglu R, Muslumanoglu AY (2009) The effects of percutaneous nephrolithotomy on renal function in geriatric patients in the early postoperative period. Int Urol Nephrol 41:219–223
15. Traxer O, Smith TG 3rd, Pearle MS, Corwin TS, Saboorian H, Cadeddu JA (2001) Renal parenchymal injury after standard and mini percutaneous nephrostolithotomy. J Urol 165:1693–1695
16. Wadhwa P, Aron M, Bal CS, Dhanpatty B, Gupta NP (2007) Critical prospective appraisal of renal morphology and function in children undergoing shockwave lithotripsy and percutaneous nephrolithotomy. J Endourol 21:961–966
17. Webb DR, Fitzpatrick JM (1985) Percutaneous nephrolithotripsy: a functional and morphological study. J Urol 134:587–591