

Original Article

Early Effects of Percutaneous Nephrolithotomy on Glomerular Filtration Rate and Determining the Potential Risk Factors Responsible for Acute Postoperative Renal Function Impairment

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Abstract

Background: In this study, the early effects of percutaneous nephrolithotomy (PCNL) on glomerular filtration rate (GFR) was assessed in different postoperative times and likewise, we determined the correlation of different variables with significant postoperative GFR drop after PCNL.

Materials and Methods: Patient records of 486 cases that had undergone PCNL from January 2010 to October 2011 were reviewed retrospectively. GFR in six hours, one, two and three days after PCNL and in the discharge day were calculated and then compared with preoperative level. Correlation between different variables (Perioperative hemorrhage, co-morbidities, previous stone surgery, renal anomaly, number of access, stone burden and location) and risk of acute postoperative renal function impairment (GFR drop greater than 25%) were assessed.

Results: Mean preoperative GFR was $87.85 \pm 29.41 \text{ ml/min/1.73m}^2$ which decreased to 86.18 ± 28.77 , 78.45 ± 28.74 , 78.79 ± 26.94 , 84.24 ± 29.71 and 86.18 ± 28.77 in 6, 24, 48 and 72 hours after surgery and discharge day post PCNL, respectively. GFR significantly decreased in one and two days after surgery (p value < 0.0001 and p value < 0.05) but returned to near preoperative values in 3th post PCNL day. Among different variables, only perioperative bleeding (Cut-off point for serum hemoglobin drop was 2.8 mg/dL) was concomitant with significant postoperative renal function impairment.

Conclusion: Our findings revealed that co-morbidities, large or multiple stones, multiple punctures and previous history of stone surgery have no significant impact on surgical outcomes. Postoperative GFR returned to near preoperative values in a few days after operation. Avoidance of significant perioperative bleeding is an important point to prevent post PCNL renal insufficiency.

Keywords: Percutaneous nephrolithotomy, Glomerular filtration rate, Renal insufficiency, Risk factor

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Introduction

Nowadays, PCNL is the standard treatment of stones larger than 2 cm, complex and Staghorn NBM

renal calculi¹. Some previous studies revealed that hospitalized, cost of surgery, postoperative morbidity and discomfort is lower and patient

satisfaction is higher in PCNL than open surgery². An animal study described that renal function decreases immediately after PCNL and slowly increases, afterwards³. Likewise, similar results have been reported in human model by another study⁴. There are few studies about early GFR changes after PCNL with limited sample size^{5,6} and some previous clinical reports focused on long-term outcome of PCNL on renal function⁷.

Although PCNL is a safe and effective technique even in difficult cases, but different variables may be affected the final outcomes of PCNL and predispose the patient to postoperative renal function impairment.

In this study, estimation of GFR was measured in different times in the early postoperative period and then early effects of PCNL on GFR was assessed and likewise, we determined the correlation of different variables with significant postoperative GFR drop (greater than 25% drop) after PCNL.

Methods

We reviewed the patient records of 486 cases older than 18 years that had undergone percutaneous nephrolithotomy from Jan. 2010 to Oct. 2011 in Labbafinejad medical center, in Tehran capital city of Iran.

PCNL technique: All PCNL was performed by two endourologic fellows and one experienced endourologists under general anesthesia. Ureteral catheter was fixed and then stone access made by using fluoroscopic guidance; Tract was dilated using one-stage technique until 28 to 30 Fr. Stones were extracted by grasper after breaking them by pneumatic lithotripter and/or holmium laser. Nephrostomy tube insertion was optional and dependent to surgeon preference. Different

variables consisted of age, stone burden, previous history of stone surgery, renal anomaly, number of access, operative time, perioperative bleeding and blood transfusion, previous history of diabetes mellitus, ischemic heart disease (patients with previous history of CCU admission), hypertension, Cerebrovascular accident (CVA) and renal insufficiency (GFR<60 mL/min/1.73m²) were assessed. GFR and serum hemoglobin level were measured at different times: before operation, 6, 24, 48 and 72 hours after surgery and discharge day. Decrease in hemoglobin was defined as difference between the lowest level of postoperative hemoglobin and preoperative level and GFR rising determined as difference of GFR at discharge time from preoperative GFR.

GFR was determined according to Cockcroft-Gault formula and the patients were divided to four categories according to Rife classification [8] as below:

1. GFR drop less than 25%
2. GFR drop greater than 25% and less than 50% (At risk for renal failure)
3. GFR drop greater than 50% and less than 75% (Injury)
4. GFR drop greater than 75% (Acute renal failure)

Statistical analysis was performed using SPSS software version 19. Impact of different variables

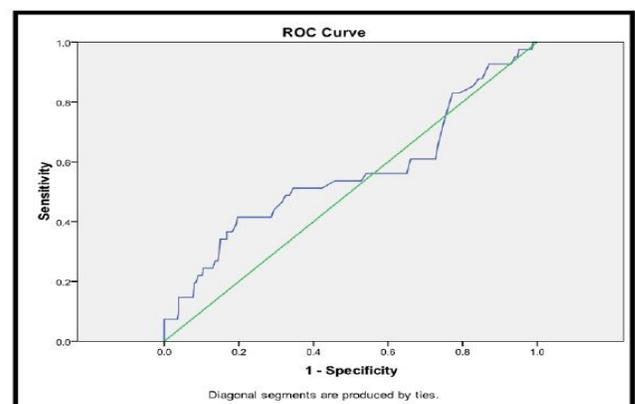


Figure 1. ROC curve of serum hemoglobin drop cut-off point in patients with acute postoperative GFR decrease greater than 25%.

on significant decrease in GFR (GFR drop greater than 25%) after PCNL was analyzed using independent t-test and ANOVA test. Two tailed $p < 0.05$ was considered statistically significant.

Results

486 patients consist of 316 male and 170 female with mean age of 45.63 years (patients younger than 18 years old were excluded) were enrolled in this study.

Mean preoperative GFR was lower in 21 patients older than 70 years old than younger cases (63.25 ± 9.13 Vs. 71.43 ± 12.25 mL/min/1.73m²) but no significant difference regarding to post PCNL decrease in GFR was detected between these patients and cases younger than 70 years old (p value > 0.05). All data about stone side, stone location and different site of punctures has been presented in table 1. Mean preoperative GFR was 87.85 ± 29.41 mL/min/1.73m² and mean GFR at 6 hours, 1st day, 2nd day, 3th day and discharge day was 82.24 ± 29.71 , 78.79 ± 26.94 ,

78.45 ± 28.74 , 84.24 ± 29.71 and 86.18 ± 28.77 , respectively. These results revealed that GFR decreases significantly at one and two days after surgery (p value < 0.0001 and p value < 0.05) but returned to near preoperative values at 3th post PCNL day.

Mean preoperative GFR in patients with previous history of diabetes mellitus (DM), ischemic heart disease (IHD), hypertension (HTN) and Cerebrovascular accident (CVA) was 71.46 ± 25.53 , 74.69 ± 2.62 , 76.51 ± 25.81 and 64.69 ± 23.17 mL/min/1.73m², respectively. Assessment of GFR at discharge day in the aforementioned patients revealed that PCNL has no detrimental effects on renal function (Table 2) (p value > 0.05 in DM, p value > 0.05 in IHD, p value = 0.202 in HTN and p value = 0.937 in CVA).

Mean preoperative GFR in patients with chronic renal insufficiency (GFR < 60 mL/min/1.73m²) was 33.92 ± 1.62 and mean GFR at 6 hours, 1st day, 2nd day and discharge day was 31.02 ± 1.14 , 32.66 ± 1.43 , 35.62 ± 1.67 and 35.50 ± 1.93 mL/min/1.73m², respectively. There was no significant difference between these patients and cases with acceptable renal function (p value > 0.05).

Table 3 reveals that multiple punctures (p value > 0.05), previous history of renal surgery (p value > 0.05), staghorn stone (p value > 0.05), and renal anomaly (p value > 0.05) have no significant adverse effects on renal function.

Mean preoperative GFR in patient with multiple punctures (more than one access) was 89.57 ± 30.7 and mean GFR in 6 hours, 1st day, 2nd day and discharge day was 80.91 ± 26.45 , 77.7 ± 24.5 , 75.04 ± 27.5 and 83.91 ± 31.3 mL/min/1.73m², respectively. Significant decrease in GFR was observed after operation and returned to near preoperative level in discharge day (p value > 0.05) but did not reach to basic level. Likewise, there

Table 1: Data about demographic characteristics, stone location and puncture.

Male	316
Female	170
Right	234
Left	252
Pelvic stone	63
Staghorn	89
Upper ureter	6
Calyceal	60
Semi-Staghorn	233
Upper calyx puncture	52
Middle calyx puncture	85
Lower calyx puncture	349

was no significant difference between patients with single puncture and patients with multiple punctures (p value >0.05).

207 patients (42.5%) underwent tubeless PCNL and our results indicated that tubeless surgery was not resulted in significant decrease in GFR (p value >0.05).

Mean preoperative GFR in patients with Staghorn (average stone size: 5.3cm) and non-Staghorn stone (average stone size: 3.6cm) was 80.75 ± 25.18 and 89.73 ± 30.56 mL/min/1.73m², respectively. Mean GFR level in discharge day in patients with staghorn and non-staghorn stone was 81.38 ± 23.58 and 82.93 ± 34.04 mL/min/1.73m², respectively. Our findings revealed stone size has no significant adverse effect on GFR after PCNL (p value >0.05).

No significant difference was noted regarding to decrease in mean GFR between patients with

renal anatomical anomaly and cases with normal kidney structure (p value >0.05).

Mean operative time in patients with more than 25% decrease in GFR was 100.15 ± 31.8 minutes and 94.3 ± 28.56 minutes in patients with lower than this limit. Our findings confirmed that operative time is not a risk factor for post PCNL impairment of renal function.

105 patients experienced more than 25% decrease in GFR after surgery. Cut-off point of serum hemoglobin drop was 2.8 mg/dL (Figure 1) in these cases and mean serum hemoglobin drop in patients with less than 25% decrease in GFR was 1.74 mg/dL. These findings was compatible with significant difference between them (p value <0.05) and it seems that this cut-off point of decrease in serum hemoglobin may be a risk factor for acute postoperative renal function impairment.

Table 2: Effect of co-morbidities on glomerular filtration rate (GFR) after PCNL

Underlying disease	Number of patients	Pre-op GFR	Discharge GFR	P Value
Diabetes mellitus	57	71.46 \pm 25.53	70.43 \pm 34.76	0.991
Hypertension	101	76.51 \pm 25.81	74.23 \pm 29.98	0.202
Cerebrovascular accident	10	64.69 \pm 23.17	60.12 \pm 19.27	0.937
Ischemic heart disease	11	74.69 \pm 24.62	73.12 \pm 35.4	0.133
Chronic renal insufficiency (GFR <60 cc/min)	10	33.92 \pm 1.62	35.5 \pm 1.93	0.67

Table 3: Effects of different variables on GFR after PCNL

Variable	Number of patients	Pre-op GFR	Discharge GFR	P Value
More than one access	49	89.57 \pm 30.77	83.91 \pm 31.3	0.138
Staghorn stone	89	80.75 \pm 25.18	81.38 \pm 23.58	0.618
Rena abnormality	13	96.65 \pm 43.32	95.5 \pm 24.29	0.467
Previous history of stone surgery	133 (one surgery: 117) (more the one: 16)	86.08 \pm 31.2	84.37 \pm 28.93	0.539

Discussion

Previously, some clinical studies revealed that renal function not affected significantly by PCNL in long-term follow-up⁷ but precise assessment of immediate PCNL effect on glomerular filtration rate and determining the potential risk factors for acute renal failure after surgery have not been elucidated, obviously.

Handa et al. demonstrated that GFR and renal plasma flow in pig model decrease immediately after PCNL and return to the preoperative level at 72 hours later. This animal study described that vasoconstriction and then renal perfusion and filtration drop will be happened in both kidneys after PCNL in one side⁹. Likewise, Nouralizadeh et al. followed 94 patients after PCNL in early postoperative period and demonstrated that GFR decreases immediately after PCNL and slowly increases in third day⁵. James and their colleagues evaluated renal function in 19 patients who had undergone PCNL and revealed that renal function preserved in 16 cases (84%) and improved in 7 cases (37%) after measurement of renal function by using MAG-3 scan¹. Urivetsky et al. measured the lysozyme activity in urine of 42 patients with history of PCNL. Lysozyme activity increased noticeably in eight cases but returned to normal rang after three days⁶. Assessment of Isotope scan in 11 patients with history of PCNL in Ekelund study showed that renal function not affected by focal small parenchyma scars that occurred after PCNL¹⁰. Our findings regarding to estimated GFR assessment in different times of early postoperative period revealed that estimated GFR as a marker for renal function status decreases significantly on 1st and 2nd post PCNL days and returns to preoperative level in three days after

surgery.

Pankaj et al. followed 14 patients with mean age of lower than 13 years old that had undergone PCNL and extracorporeal shock wave lithotripsy (ESWL) and revealed that these modalities compelled no morphologic and functional impairment¹¹. Adem and their colleagues compared PCNL outcomes in 64 geriatric patients with mean age of 70.4±4.2 years and 657 patients with mean age of 40.9±12.7 years and reported that postoperative GFR to preoperative GFR ratio is higher in older patients than younger cases. Thus, it seems that according to this study, PCNL is a safe approach for stone management in geriatric cases¹². Mean preoperative GFR was lower in patients older than 70 years old than younger cases but post PCNL GFR changes were nearly similar to younger patients and no significant difference was observed (p value>0.05).

Bilen et al. demonstrated that PCNL has no adverse effects on renal function in patients with history of chronic renal insufficiency (GFR less than 60 ml/min/1.73m²). They followed 185 patients with preoperative poor renal function after PCNL and revealed that post PCNL GFR improved in 25% of patients (greater than 60 mL/min/1.73m²) and no cases required to dialysis¹³. In our study, 10 cases had preoperative GFR less than 60 mL/min/1.73m² that 2 cases revealed GFR improvement in discharge day (greater than 60 mL/min/1.73m²) and only one patient had post PCNL GFR decline in discharge time but no one required to dialysis; so our findings and previous reports confirmed that PCNL does not increase the rate of acute renal failure (ARF) in patients with chronic renal insufficiency and can be performed with proper results.

Rajash et al. performed PCNL in 23 cases with one access and in 10 cases with two accesses and

compared GFR and renal plasma flow in the aforementioned groups and finally concluded that post PCN GFR drop was similar in both groups and no significant difference detected⁹. Our results revealed that multiple access PCNL is not a risk factor for significant post PCNL GFR drop but GFR in discharge time was lower than preoperative level and required to more prolonged time to return to the preoperative value. Another study reported that increase number of shock from 2000 to 8000 in ESWL may be led to delayed return of renal function to normal status; thus perhaps similar event may be happened in multi-access PCNL¹⁴.

Sharifiaghdas et al. measured urinary level of β 2-microglobulin as a marker for assessment of tubular damage after PCNL in early postoperative period. They concluded that this urinary marker will be normal after 7th post PCNL day but the likelihood of tubular damage was higher in patients with history of DM and higher preoperative serum creatinine¹⁵. We found no study about the pure impact of DM on estimated GFR after PCNL and we did not measure the tubular marker to determine DM effects on tubular function after PCNL but it seems that controlled DM has no adverse effects on estimated GFR.

Falahatkar et al. compared the outcomes of PCNL in 36 patients with previous history of open renal surgery on the ipsilateral kidney and 68 cases with no previous renal surgery and their findings were compatible with no significant difference in safety and efficacy of PCNL between these two groups¹⁶. Another study by Resorlu et al. confirmed that previous history of open nephrolithotomy or failed ESWL have no adverse effects on stone clearance and complications in these patients¹⁷. 133 patients in our experience had previous history of renal

stone surgery and no significant GFR drop occurred after repeat percutaneous surgery.

Post PCNL GFR drop greater than 25% was recorded in 105 cases that experienced mean 2.8 mg/dl serum hemoglobin drop. This limit of hemoglobin drop was a risk factor for noticeable GFR decrease and there was a significant difference in this group of patients comparing to patients had mean serum hemoglobin drop lower than 1.74 mg/dL (p value<0.05).

We accept that this study was a retrospective assessment and co-existence of two or more risk factors (for example DM and HTN in a patient with Staghorn stone) in a group of cases may be modified the final results and perhaps, additive effects of these variables create the different findings. Likewise, matching of the each aforementioned variable in a large group of patients requires some separate studies with different design.

Conclusion

It seems that compatible with the previous reports, large or multiple stones, coexisting medical problems and previous history of stone surgery have no negative impact on surgical outcomes. Postoperative GFR returned to near preoperative values in a few days after operation. Avoidance of significant perioperative bleeding is an important point to prevent post PCNL renal insufficiency.

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