FUNCTIONAL IMPROVEMENT AFTER PERCUTANEOUS NEPHROLITHOTOMY IN THE SOLITARY KIDNEY PATIENTS

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ABSTRACT

Background

Percutaneous nephrolithotomy is regarded as the treatment of choice for large and complex renal stones. Despite of its safety and efficacy, it remains a crucial challenge for endourologist in soiltary kidney patients

Objectives

To assess the effect of percutaneous nephrolithotomy (PNL) on renal function measured by glomerular filtration rate (GFR) in solitary kidney patients

Materials and Methods

The records of 25 patients with age range of (18-66) years with a solitary functioning kidney that had undergone PNL from September 2015 October 2017 in Sulaymani Teaching Hospital were prospectively analyzed. Serum creatinine was measured preoperatively and 7 days postoperatively. Preoperative, operative and postoperative details were analyzed for each patient with respect to change in eGFR between pre and postoperative period. Multivariate analysis was done to find relations between variable, p-value < 0.05 was considered as significant.

Results

There was a significant increase in the mean postoperative eGFR in (P-value <0.001). Age, gender, BMI, DM, history of ipsilateral renal surgery, grade of hydronephrosis, stone complexity and location have no considerable impact on postoperative renal function impairment (p-value >0.05). Operative time, the number of working tracts and the size of amplatz sheath also have no impact on the deterioration of renal function. Hypertension caused a significant decrease in the postoperative eGFR (p-value 0.01) and blood loss more than average (Hb drop >1.072gm/dl) caused either stable or decrease in the postoperative eGFR (P-value 0.03).

Conclusion

Percutaneous nephrolithotomy is safe in solitary kidney patients and early renal function improvement is anticipated. History of hypertension and bleeding are the two blamed risk factors that cause acute postoperative renal function deterioration.

Keywords: *Percutaneous Nephrolithotomy, Renal Function, Renal Stone, Solitary kidney.*

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INTRODUCTION

Percutaneous nephrolithotomy (PNL) for stones in solitary kidney patients remains a crucial challenge for endourologist. Despite technical analogy in comparison to two viable kidneys, major complications like uncontrolled bleeding that requires embolization or even nephrectomy may leave the patient anephric and compulse renal replacement therapy [1,2].

Although sufficient clinical skill exists regarding PNL procedure and outcomes, data about its impact on the renal function of the affected side is meagre. This is due to the presence of the spared contralateral kidney which compensates for the potential impairment of the renal function. That is why evaluation of renal function in single kidney cases that underwent PNL is indispensable [3]. Some studies suggested that there are either no overall changes or even improvement in the renal function during the postoperative period, while others demonstrated acute renal function deterioration 48 hours postoperatively. The latter was found to be a temporary derangement and six months later renal function would either be preserved or enhanced [4-6].

The decline in the renal function at the early postoperative period has been postulated to be due to the effect of anesthetic or antibiotic medication [7]. However certain comorbid conditions like diabetes mellitus (D.M) and atherosclerosis has been condemned as risk factors for post PNL deterioration of renal function [8].

The aim of the current study was to assess the effect of PNL on renal function in solitary kidney patients with renal stone and to evaluate risk factors for acute renal function deterioration.

METHODS

Clinical Data

This prospective study has gained acceptance of the ethical committee of University of Sulaimani. It has been done on 25 patients with solitary functioning kidney with renal stones who underwent PNL from September 2015 to October 2017. Written informed consent has been taken from all cases. They were evaluated by medical history, physical examination, biochemical and hematological investigations with preparing cross-matched blood for all cases. An abdominal and pelvic ultrasound (US) with or without intravenous urography (IVU) was done for all cases. In patients with preoperative impaired renal function, abdominal computed tomography was done as a preoperative diagnostic imaging work up. Stones were classified based on complexity Guy's stone scoring system which comprises 4 grades using intravenous pyelography or abdominal CT scan [9].

The estimated glomerular filtration rate (eGFR) of each patient was determined preoperatively depending on the age, weight, sex and serum creatinine of the patient and the equation is:

CCr={((l 40–age) x weight)/(72xSCr)} for male

CCr={((l 40–age) x weight)/(72xSCr)}x 0.85} for female

The mean eGFR of all patients identified. The preoperative eGFR of each patient was classified according to the 5-stage classification of chronic kidney based on National Kidney Foundation guidelines [10].

The surgical procedure and equipment

All patients had received prophylactic antibiotics at induction of anesthesia according to the policy of the microbiology department of the hospital and the dose adjusted to the stage of chronic kidney disease of the patients.

The procedure is started in dorsal lithotomy position and the ipsilateral ureter was catheterized using standard open tip ureteric catheter preloaded with hydrophilic flexible tip guide wire (Boston Scientific, Quincy, MA, USA) through a rigid cystoscope, then 16Fr Foley catheter was inserted. The patient then was converted to prone position and enough support for the chest and pelvis is done using proper size towel coils.

The pelvicalyceal system was visualized through retrograde contrast injection via the ureteral catheter. Percutaneous renal access was achieved through an appropriate posterior calyx under C-arm fluoroscopy (Siemens, Berlin, Germany) guidance using an 18-G needle (Cook Medical Inc., Bloomington, IN, USA). Successful access was indicated by the free flow of clear fluid from the needle. At once a hydrophilic flexible tip guide wire is passed to the renal pelvis. A working channel was established using serial plastic (cook Inc.) or metallic dilator system under fluoroscopy control to (16- 30fr). Amplatz sheath (Boston Scientific) was placed over the dilated system. A rigid nephroscope (Karl-Storz, Tuttlingen, Germany) was then placed directly into the kidney through the amplatz. Fragmentation of stone burden was accomplished using a pneumatic lithotripter. Forceps and irrigating fluid were used to

remove stone fragments.

Flexible nephroscope was used routinely in all cases to check all calyces and wash out all small fragments that were difficult to reach by the rigid nephroscope. In cases where the stones in the calyces that was inaccessible by rigid nephroscope, flexible nephroscope also was used and the stone fragmented by holmium laser (Storz).

Stone clearance was determined by fluoroscopy in radiopaque stones and residual fragments were identified and managed accordingly till complete clearance. At the end of the procedure, the ureteric catheter was removed and antegrade double J stent was inserted in all cases routinely which were removed 2weeks later [11]. A Foley catheter was fixed as nephrostomy tube in all cases.

Postoperative Care

Postoperatively vital signs, urine output and color follow up were done for all cases. Hemoglobin checked 24 hours later and if necessary Hb checks were performed at more frequent intervals for specific cases.

The urethral catheter and nephrostomy tube were removed on first postoperative day, but in cases of bleeding and pelvicalyceal perforation, the nephrostomy kept for longer time. During the 7th to10th postoperative day another s.creatinine has been measured for all patients and eGFR determined accordingly.

Preoperative, operative and postoperative details were recorded and analyzed for each patient with respect to change in eGFR between pre and postoperative period.

We analyzed preoperative factors: age, sex, body mass index (BMI), the presence of hypertension, diabetes mellitus, history of ESWL, the degree of hydronephrosis, previous open renal surgery, PNL, the location of the stones and stone complexity.

The operative factors analyzed were the number of access tracts, mean duration of operation (minutes) and size of amplatz. Postoperatively total Hb drop calculated for all patients and those transfused were identified.

Blood loss determined as changes in hemoglobin concentration difference between preoperative and24 hour postoperative hemoglobin concentrations.It was considered that a one unit blood transfusion increase the hemoglobin level by 1 gram/dl and hematocrit by 3%. Therefore drops in hemoglobin and hematocrit were calculated as follows:

(Preoperative Hb - postoperative Hb) + (number of units transfused × 1 g/dL Hb per unit transfused) [12].

The average blood loss postoperatively was 1.072 gram/dl. Patients were classified into two main groups: those with Hb drop above average (1.072g/dl) and those with Hb drop below average.

Statistical Analysis

The data was transported into SPSS (version 20, IBM SPSS Statistics Ink. USA) computer program software for statistical analysis. Descriptive statistics (mean, standard deviation, minimum, maximum, numbers, and percentage) were calculated for variables, multivariate analysis was done to find the relations between variables. A p-value < 0.05 was considered as significant.

RESULTS

In total, 25 patients (19 male, 6 female) who have undergone PNL were analyzed. Table (1) demonstrates the general characteristics of the patients. A wide range of patient ages (18-66) years with a mean±SD of 46.6±12.5) were included in the study. The proportion of male patients was higher than females (76% and 24% respectively). With regards to the weight, the overweight group ranks first with 44% and obese comes next with approximately one-third of patients. In majority of the cases the cause of the solitary kidney was due to the congenital renal agenesis or small hypoplastic kidneys. Table (2) shows the mean and standard deviations of age, BMI, operative time and preoperative and postoperative eGFR, s.creatinine and hemoglobin.

Regarding the preoperative variables are shown in the Table (3). Twenty-eight percent of subjects were diabetic, almost one-third of patients (32%) were hypertensive. Most of the patients were in stage one and two CKD creatinine clearance. Moreover, mild and moderate hydronephrosis was found in 52% and 36% respectively. According to Guy's stone score stage 1 and 2 found in 32% and 36% of patients. Sixty percent of the stones were located in the pelvis and calyces (combined pelvic and calyceal stones)

Concerning operative factors: operative time was less than 40 minutes in 56% of the cases. The single puncture was used in 24 patients (96%). The size of amplatz ranged from 22-30 Fr was used in 18 patients (72%).

Concerning the postoperative variables, the mean±SD of Hb drop was 1.072±1.39 g/dl. Hb drop ≥1.072 was found in 8(32%) of patients. Blood transfusion and stone free rate were 12%, 96% respectively. Mean hospital stay was 36 hour. Four (16%) cases developed postoperative fever that managed by proper antibiotics. One (4%) case had a residual stone in the upper pole of the kidney that managed by SWL one month later.

Analysis of the relevant factors and their relation with postoperative eGFR, multivariate analysis was done (Table 4) and (table 5). Our study showed that age, gender, BMI, DM, history of ipsilateral renal surgery (open and PNL), grade of hydronephrosis, stone complexity and location of the stones have no considerable impact on postoperative renal function impairment (p-value >0.05).

The operative variables, operative time, number of working tracts and the size of amplatz sheath also have no impact on the deterioration of renal function (p value>0.05)

However, there was a significant improvement in the postoperative eGFR in relation to the preoperative eGFR (P-value <0.001).

Our results showed that hypertension caused a significant decrease in the postoperative eGFR (p-value 0.01) and blood loss more than average (Hb drop >1.072gm/dl) has either no effect or decrease in the postoperative eGFR (P-value 0.03).

Table 1. General characteristics of the study population.

General characteristics	Number	Percentage
Gender		
Male	19	76%
Female	6	24%
BMI		
Normal	5	20%
Over weight	11	44%
Obese	8	32%
Morbidly obese	1	4%
Cause of solitary kidney		
Congenital agenesis	13	52%
Small atrophic	10	40%
Nephrectomy	2	8%

Table 2. Minimum, maximum, mean, andsStd.deviation of variables.

Variable	Minimum	Maximum	Mean	Std. Deviation
Age(year)	18.00	66.00	46.6000	12.50666
BMI(Kg/m2)	19.20	38.00	28.8080	4.48877
Preoperative Hb (gm/dl)	10.50	17.30	13.3920	1.67802
Postoperative Hb(gm/dl)	8.50	15.60	12.4560	1.77320
Preoperative Creatinne (mg/dl)	0.70	7.80	1.5112	1.45384
Postoperative Creatinne (mg/dl)	0.50	3.74	1.1712	0.71673
Preoperative eGFR(ml/min/1.73m²)	16.90	185.68	91.9168	39.14732
PostoperativeeGFR(ml/min/1.73m²)	27.54	248.90	108.6248	46.97397
Operative time (minutes)	20.00	120.00	40.0000	21.79449

Table 3. Preoperative findings in the study population.

Pre-operative findings	Number	Percentage
Diabetes mellitus	7	28%
Hypertension	8	32%
CKD (ml/min/1.73 m2 GFR)		
Stage 1 (90 or greater)	12	48%
Stage 2 (60–89)	9	36%
Stage 3 (30–59)	2	8%
Stage 4 (15–29)	2	8%
Stage 5 (less than 15)	0	0%
Degree of hydronephrosis		
No	2	8%
Mild	13	52%
Moderate	9	36%
Severe	1	4%
Previous open renal surgery	3	12%
Previous PNL	2	8%
SWL	5	20%
Location of the stones		
Pelvic stone	6	24%
Calyceal stone	4	16%
Combined stone (pelvic and calyceal)	15	60%
Guys grade		
1	8	32%
2	9	36%
3	6	24%
4	2	8%

Table4. Multivariate analysis of preoperative factors.

Variable	No.	%	Mean preoperative eGFR ml/ min/1.73m2	Mean postoperative eGFR ml/ min/1.73m2	P value
Age group (years)					
<46	9	36%	108.3	128	0.51
>46	16	64%	82.6	97.5	
Sex					
Male	19	76%	95.27	111.6	0.57
Female	6	24%	81.2	99.07	
BMI					
Normal	5	20%	90.3020	103.8300	
Overweight	11	44%	84.3236	110.9573	0.09
Obese	8	32%	91.6463	103.4250	
Morbidly obese	1	4%	185.6800	148.5400	
Hpertension					
Yes	8	32%	98.1506	74.8888	0.01
No	17	68%	78.6700	124.5006	
Diabetes					
Yes	7	28%	69.0057	82.0714	0.07
No	18	72%	100.8267	118.9511	
Open sugery					
Yes	3	12%	108.6800	138.5233	0.24
No	22	88%	89.6309	104.5477	
PNL					
Yes	2	8%	99.7350	141.5250	0.31
No	23	92%	91.2370	105.7639	
Degree of hydronephrosis					
No, mild	15	60%	96.9107	112.4987	0.62
Moderate, severe	10	40%	84.4260	102.8140	
Location of the stones					
Pelvic stone	6	24%	87.36	115.68	0.59
Calyceal stone	4	16%	115.005	135.26	
Combined stone	15	60%	87.58	98.69	
Guys grade					
1	8	32%	92.0138	108.4075	
2	9	36%	85.5733	114.4267	0.85
3	6	24&	87.7550	95.1133	
4	2	8%	132.5600	123.9200	

Table 5. Multivariate analysis of operative and postoperative variables.

variable	No.	Percentages	Mean preoperative eGFR ml/min/1.73m²	Mean postoperative eGFR ml/min/1.73m²	P value
Baseline eGFR	25	100%	91.9168	108.62	<0.001
Operative time					
<40	14	56%	92.247	113.629	0.4
>40	11	11%	91.496	102.225	
No of tracts					
1	24	96%	94.6467	112.0033	0.07
2	1	4%	26.4000	27.5400	
Size of sheath					
Mini	7	28%	91.88	113.7	0.23
22-30	18	72%	91.93	106.6	
Hb drop					
>1.072	8	32%	113.7	116.08	0.03
<1.072	17	68%	81.62	105.11	

DISCUSSION

PNL is the treatment of choice for large and complex renal stones with high success rates and acceptable complications. Unceasing advancement in instruments and techniques helped urologists to perform this procedure in single kidney patients [13].

An important goal of this minimally invasive procedure is less glomerular loss and scar formation. Many studies have supported the superiority of PNL to open surgery regarding lower morbidity; shorter operative time and shorter hospital stay as well as an earlier return to work [14, 15].

There are few studies in the literature addressing the early effect of PNL on GFR. The initial trial of determining the impact of PNL on renal function was conducted by Handa et al. They observed that GFR and renal plasma flow in pigs decreased immediately after PNL and returned to the preoperative level after 72 hours, they described that vasoconstriction and then renal perfusion and filtration drop would happen in both kidneys after PNL in one side [16]. In the present study, we have measured serum creatinine of all patients in a week postoperatively to avoid the temporary period of GFR drop. We used the Cockcroft-Gault equation for measuring the eGFR and we found significant improvement in the baseline GFR postoperatively. The mean preoperative GFR increased from 91.916±39.1 ml/min/1.73 m^2 to 108.62±46.9 ml/min/1.73m^2 and the increase was statistically significant with a p-value of <.001. This finding is consistent with what has been observed by Segura and colleagues. They denied to report detectable compromise in renal function in 15 patients with solitary kidneys immediately after PNL and in a retrospective study of 53 patients with solitary kidneys, Jones and associates demonstrated stable serum creatinine and overall preservation of renal function immediately after PNL, even though 26% of patients had impaired preoperative renal function [17, 18].

The long-term influence of PNL on solitary kidney patients is also addressed in the literature. Basiri et al compared the functional changes of solitary kidneys in 30 patients with another 30 patients having double kidneys. The effect of PNL on global and regional cortical activity was measured using technetium-99 m dimercaptosuccinic acid scan uptake by the kidneys before and 6 months after PNL. They concluded that renal function was preserved or improved after PNL, and the procedure had no detrimental effects on renal function [6]. Later on, this finding has been backed by El-Tabey NA et al [5]. However in the current study we were unable to follow our patients for a long time to determine the long-term effect of PNL on GFR because our center is a tertiary referral center and most of the cases were far from the center.

There are several patients, stones and operative factors that may have an impact on renal function post PNL in solitary kidney patients [5, 18]. This study revealed that age, sex, and BMI are not risk factors for post PNL renal function deterioration, the same result has been divulged by other investigators [5]. However, Canes and associates concluded that female gender is an independent protective factor of renal function

improvement after PNL [19].

There are controversies about the impact of comorbidities like DM and hypertension on renal function post PNL. Sharifiaghdas and his colleagues recapitulated that DM is a risk factor for post PNL renal function deterioration [21], while other authors rejected this association like our results [5 ,6, 18, 19]. Hypertension is also having no impact on post PNL GFR drop according to the literature [5, 6, 18 ,19], but our results demonstrated the reverse that the mean GFR decreased From(98.15 ml/min/1.73m^2) to (74.88ml/min/1.73m^2) which is statistically significant with a p-value of 0.03, however further studies recommended to prove this association.

One of the most imperative considerations during PNL on solitary kidneys might be the potential effect of multiple access procedures on renal function. Although a patient needed more than one access tract in the current study (4%), but the postoperative GFR remained the same, this finding is financed by other investigators [16] while, Gorbachinsky et al and Nasr et al found the reverse, they confirmed that multiple access tract is an independent factor of depreciation of renal function post PNL in solitary kidneys [5, 21], this had led one think of alternative to multiple access tracts which is the combined flexible nephroscope or flexible ureteroscopic techniques with a single percutaneous access to curtail the calamitous impact of multiple access tracts. We used antegrade flexible nephroscope in all cases because all procedures have been done in the prone position.

Controversy still exists whether mini PNL has the potential effect on renal function of the solitary kidney. Traxer et al compared the extent of renal injury incurred by differently sized nephrostomy tracts in female farm pig undergoing11- or 30-F percutaneous nephrostomies. They reported that the larger tract did not cause a fundamental functional renal loss in comparison to the smaller one [14]. Our results also demonstrated that larger amplatz sheaths had no significant impact on post-procedure renal function deterioration in comparison with mini PNL.

Another influential risk factor of post PNL renal function depreciation is bleeding and increased blood loss. It should be noticed that single kidney is a risk factor for hemorrhage because of compensatory hypertrophy of renal parenchyma due to a solitary kidney, this has been observed by El-Nahas et al [22]. Nasr et al noticed that severe bleeding is a risk factor of a drop of GFR post PNL in the solitary kidney [5]. We noticed in our study that the cut-off Hb drop of >1.07 gm/dl with a mean Hb drop of 2.7gm/dl study group GFR is either the same or decreased in comparison with the Hb drop of < 1.07 gm/dl study group postoperative GFR which revealed observable improvement.

There are certain limitations to our study like a small number of studied patients and short-term follow up of the patients.

In conclusions, based on our results percutaneous nephrolithotomy is safe in solitary kidney patients and early renal function improvement is anticipated. History of hypertension and bleeding are the two blamed risk factors that cause acute postoperative renal function deterioration.

Conflict of interest

The authors have no conflict of interest.

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