Original Article

Factors influencing recoverability of renal function after urinary diversion through percutaneous nephrostomy

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Abstract

Context: Various factors predict recoverability of kidney function preoperatively. Placement of percutaneous nephrostomy (PCN) and measuring the differential creatinine clearance (diff. %CrCl) is still regarded as a simple and reliable method.

Aims: The aim was to evaluate correlation between renal cortical thickness (CT), hydronephrosis, intrapelvic pressure (IPP), PCN output, renal morphological factors such as length, width, echogenicity, corticomedullary differentiation (CMD), status of c/l kidney, and presence of infection which can predict recoverable function.

Settings and Design: A prospective study done between July 2013 and June 2014 in Urology Department.

Subjects and Methods: Hundred and sixty patients of supravesical obstruction for various causes who need PCN either due to chronic renal failure or nonvisualized kidney on contrast study, were included. IPP was measured during PCN placement. After 4 weeks 24 h urine was sent for CrCl and urine pH.

Statistical Analysis Used: Correlation of continuous and categorical variables with dependent variable (diff. %CrCl) was formulated using spearman correlation and Mann–Whitney U test. Simple and multiple linear regression analysis were performed.

Results: The study includes 160 patients with median age of 65.5 years. Hydronephrosis were due to stone in 76 (47.5%), pelviureteric junction obstruction (PUJO) in 40 (25%), cancer in 32 (20%), others in 12 cases (7.5%). IPP was < 10 cm H_2O in 48 (30%); 10–20 cm H_2O in 64 (40%) and > 20 cm H_2O in 48 (30%). There was significant correlation between IPP and diff. %CrCl with correlation coefficient $\rho = 0.509$ ($P = 0.0001$).

Conclusions: CT, parenchymal echogenicity, CMD, pre-PCN creatinine, and status of c/l kidney are the only independent variables which can predict the renal function while other variables like renal size, urine output, infection, hydronephrosis lost their statistical significance in multivariate analysis. Furthermore, IPP measured before PCN directly correlated with daily urine output and diff. %CrCl.

Key Words: Corticomedullary differentiation, differential creatinine clearance, intrapelvic pressure, percutaneous nephrostomy

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INTRODUCTION

Chronic obstruction commonly causes progressive renal damage. Timely intervention may be required for restoration of function either by double J stent or percutaneous nephrostomy (PCN) depending on the severity and presence of any co-existing infection and renal function. Several investigators have attempted to predict recoverability of kidney

function before definitive treatment. In this regard PCN,[1] ultrasonography (USG),[2] renal scan,[3] and urine pH[4] have been advocated with variable results. PCN in widely used to decompress as well as to see the recoverability of obstructed kidney. However, some kidneys fail to recover even after PCN due to irreversible permanent damage. If pre-PCN factors can be determined, which affect the recoverability potential, and then many unnecessary prolonged morbidities of PCN procedures can be avoided.

Methods of predicting the recoverability were studied in past too, which had included various parameter, but most of these were retrospective and had included a heterogeneous group of patients. As a general rule, renal cortical thickness (CT) is associated with poor renal outcome. But not every kidney with thin renal cortex is nonfunctional. The cost of radioisotope renography and the availability are the limiting factors. Moreover, radioisotope studies are notoriously inaccurate, especially in the case of high-grade obstruction and could not predict the recoverability of renal function.

The present study was designed in a prospective manner to evaluate correlation between renal CT, degree of hydronephrosis, intrapelvic pressure (IPP), PCN output, renal morphological factors such as length, width, echogenicity, corticomedullary differentiation (CMD), and presence of infection which can predict recoverable function.

SUBJECTS AND METHODS

Study design
This was a prospective study done between July 2013 and June 2014 in our department. During this period, a total of 170 PCN were performed in our department for various reasons. Six patients were excluded due to inappropriate PCN output monitoring. Four patients had to revise PCN due to an incorrect position. At the end, 160 patients were taken for evaluation.

Inclusion and exclusion criteria
Patients of chronic obstruction with moderate to severe hydronephrosis on account of either supravesical obstruction due to stone, stricture, PUJO; malignancy like prostate, bladder, cervix were included. These patients are either in chronic renal failure or on contrast imaging study kidney was not visualized. Patients of obstructive uropathy due to infravesical obstruction like stricture urethra were excluded. Patients with incomplete obstruction as evident by dye draining into the bladder during antegrade nephrostogram were also excluded.

Percutaneous nephrostomy procedure
After admission, complete blood count, erythrocyte sedimentation rate, blood urea, serum creatinine, serum electrolytes, X-ray and ultrasound of kidneys-ureters-bladder (KUB) region was done to find out length, width, CT, echogenicity, CMD, degree of hydronephrosis and status of opposite kidney. Noncontrast computed tomography (NCCT) was done when X-ray and USG were noninformative. Various factors like dimensions of affected kidney, status of the contralateral kidney, presence of infection, CT, echogenicity, CMD were noted. After obtaining written consent, PCN was performed under sonographic or fluoroscopic guidance in the prone position to decompress the kidney under local anaesthesia. IPP was measured at beginning of PCN using manometer with mid-axillary line as a reference point after putting 18 G puncture needle [Figure 1]. Urine was sent for culture and sensitivity. Antegrade nephrostogram was done in same setting using contrast dye. Urine output from nephrostomy tube was recorded on D1, D7, and D28. The differential creatinine clearance (diff. CrCl) of the obstructed kidney (%CrCl) defined as the percentage of CrCl of the obstructed kidney as of the total CrCl was measured after 4 weeks from 24 h urine. Urine pH, specific gravity, and electrolytes were also noted. The formula for calculating diff. %CrCl is mentioned below.[5]

$$CrCl = \frac{U_{Cr} \times U_{Vol}}{P_{Cr} \times T_{min}}$$

$$Diff. \%CrCl = \frac{CrCl \text{ of obstructed kidney}}{Total \text{ } CrCl} \times 100$$

In our study, post-PCN diff. %CrCl of more than 10 was taken as recoverable group and below was considered as poor/no recovery.[6]

Measuring renal cortical thickness
For this, all patients underwent USG KUB or NCCT, and renal CT was measured from renal capsule to the dilated renal calyx and then average was taken. Parenchymal echogenicity was considered normal if it is less than liver and spleen and abnormal if it is more than that. CMD was normal if good differentiation is present all over kidney and abnormal if it was heterogeneous or lost.

Figure 1: Photograph showing how to measure intrapelvic pressure in the prone position

Statistical analysis

The postprocedure (after 4 weeks) diff. %CrCl was taken as a reference variable to which all other variables were compared. Diff. %CrCl >10 were taken as recoverable. Renal length, width, CT, IPP, PCN output, pre-PCN creatinine, and urine pH were taken as continuous variables and its correlation with a reference variable was formulated using scatter plots with Spearman correlation coefficients. CMD, parenchymal echogenicity, infection, degree of HDN, and status of opposite kidney were analyzed as categorical variables versus reference variable using Mann–Whitney U test. Simple and multiple linear regression analysis were performed to evaluate whether these above factors has an independent influence on diff. %CrCl. All statistical assessments were two-sided and evaluated at the 0.05 level of significance using SPSS 20.0 statistical software (SPSS Inc., Chicago, IL, USA).

RESULTS

The study cohort includes 160 patients (112 male and 48 female) with median age of 65.5 years (range 24–74). The cause of hydronephrosis was renal or ureteric stone in 76 (47.5%), PUJO in 40 (25%), cancer (prostate, bladder, cervix) in 32 (20%), others in 12 cases (7.5%). Pre-PCN creatinine was <1.5 mg/dl in 40 patients (25%) and >1.5 mg/dl in 120 patients (75%). Patient's characteristics are summarized in Table 1.

CT were <10 mm in 120 (75%); 10–15 mm in 24 (15%) and >15 mm in 16 (10%) patients. IPP was <10 cm H_2O in 48 (30%); 10–20 cm H_2O in 64 (40%) and >20 cm H_2O in 48 (30%). Average IPP was 17 cm in <10 mm CT group; 16.9 cm in 10–15 mm CT group and 15.7 cm in >15 mm CT. There was no significant difference in daily PCN output from <10 mm; 10–15 mm; >15 mm CT (1257 ml, 1083 ml, 1325 ml; $P = 0.82$) however, significant difference was found in PCN output in between IPP <10 cm and 10–20 cm (954 ml, 1520 ml; $P = 0.04$).

In simple linear regression, cancer patients had a significant lower urine output (350 ml/day; $P = 0.046$) than did patients without cancer.

Continuous variables affecting recoverability of renal function are summarized in Table 2. Table 3 summarizes the frequency of normal and abnormal parenchymal echogenicity, CMD, degree of HDN, presence of infection as well as status of opposite kidney. The factors that significantly affect the recoverability of renal function after relief of obstruction included IPP, PCN output, pre-PCN creatinine, urine pH, parenchymal echogenicity, degree of HDN, CMD, infection and status of opposite kidney.

Table 1: Summary of patient (*n*=160) characteristics

	No. (%)
Age (years)	65.5 (24–74)
Gender	
Male	112 (70)
female	84 (30)
Pre-PCN creatinine	
<1.5 mg%	40 (25)
>1.5 mg%	120 (75)
Renal cortical thickness	
<10 mm	120 (75)
10–15 mm	24 (15)
>15 mm	16 (10)
Indication	
Renal or ureteric stone	76 (47.5)
PUJO	40 (25)
Cancer (prostate, bladder, cervix)	32 (20)
Others	12 (7.5)
Intrapelvic pressure (cm H_2O)	
<10	48 (30)
10–20	64 (40)
>20	48 (30)
Renal dimensions	
Length (cm)	11.7 (8.7–14.5)
Width (cm)	4.6 (3.6–6.7)
CT	Intrapelvic pressure (cm H_2O)
<10 mm group	17
10–15 mm group	16.9
>15 mm group	15.7
Intrapelvic pressure (cm H_2O)	Differential CrCl
<10	08.32
10–20	36.17
>20	37.90

CT: Cortical thickness, PCN: Percutaneous nephrostomy,
PUJO: Pelviureteric junction obstruction, CrCl: Creatinine clearance

Table 2: Continuous variables affecting recoverability of renal function after relief of obstruction (simple linear regression analysis)

Variables	β (95% CI)	*P*
Renal length (cm)	23.59 (16.88–30.30)	0.584
Width (cm)	26.78 (23.64–29.9)	0.264
CT (mm)	23.06 (19.18–26.94)	0.176
IPP (cm H_2O)	14.50 (9.97–19.04)	0.0001**
PCN output (ml/day)	12.62 (9.41–15.83)	0.0001**
Pre-PCN creatinine	21.844 (18.86–24.82)	0.003**
Urine pH	83.31 (56.38–110.24)	0.0001**

IPP: Intrapelvic pressure, CT: Cortical thickness, PCN: Percutaneous nephrostomy, CI: Confidence interval. **$P = <0.05$ significant

There was significant correlation between IPP and diff. %CrCl with correlation coefficient ρ = 0.509 ($P = 0.0001$) and between PCN output and diff. %CrCl with correlation coefficient ρ = 0.557 ($P = 0.0001$). However, there was insignificant correlation between CT with diff. %CrCl with correlation coefficient ρ = 0.229 ($P = 0.135$). The graphs are illustrated in Figure 2.

Using logistic regression analysis, we estimated diff. %CrCl value of 10 as the cut-off point to determine the best chance of stabilization or improvement of renal function after relief of obstruction.

ρ = 0.086 p = 0.579 ρ = 0.098 p = 0.527

ρ = 0.229 p = 0.135 ρ = 0.557 p = 0.000

ρ = 0.509 p = 0.000 ρ = −0.266 p = 0.001
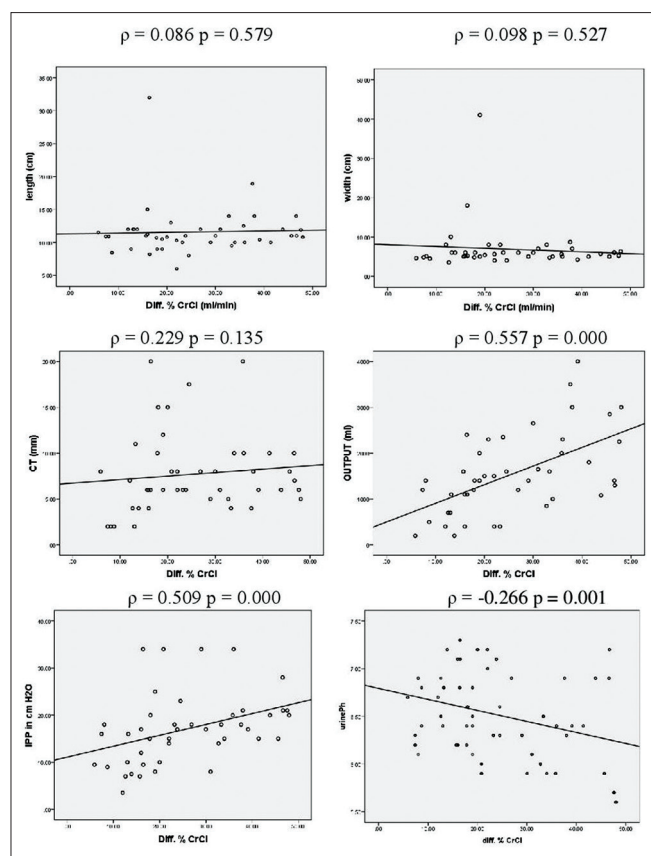
Figure 2: Correlation between continuous variables and differential %creatinine clearance of the ipsilateral kidney (univariate analysis; Spearman correlation coefficients)

On multivariate analysis, only CT, CMD, echogenicity, pre-PCN creatinine, urine pH, and status of c/l kidney sustained their statistical significance as independent factors [Table 4].

DISCUSSION

In clinical practice, various factors like duration of obstruction, age, status of contralateral kidney, presence of infection, compliance of renal pelvis can adversely affect the renal function[7] and these interacting variables make the prediction of renal function difficult. Through this study, we attempted to predict the renal function recoverability by minimizing the interacting factors. In this study, we came to know that IPP measured before PCN directly correlated with daily urine output and diff. %CrCl. Patients with IPP of <10 cm have decreased urine output as well as low diff. %CrCl and these patients finally underwent nephrectomy. Whereas patients with IPP of 10–20 cm H_2O and IPP >20 cm H_2O do fairly better after relieve of the causative factor.

Previous studies have used only univariate analysis to predict the renal function that is, each factor is studied separately without taking into consideration the effect of other relevant factors. Furthermore, other factors like the presence of infection and IPP were not included which have a significant impact on renal

Table 3: Correlation between categorical variables and differential % CrCl of the ipsilateral kidney (univariate analysis)

Variables	Kidneys (*n*)	differential % CrCl	*P**
Parenchymal echogenicity			
Normal	91	35.53	0.0001
Abnormal	69	15.94	
Corticomedullary differentiation			
Normal	103	32.2	0.0001
Abnormal	57	13.05	
Degree of hydronephrosis			
Moderate (grade 3)	56	28.42	0.018
Severe (grade 4)	101	23.60	
Presence of infection			
Yes	61	15.93	0.0001
No	99	31.20	
Status of opposite kidney			
Normal	59	22.10	0.002
Abnormal	101	27.29	

*Mann–Whitney U-test. Data in parentheses are percentages. CrCl: Creatinine clearance

Table 4: Significant variables affecting recoverability of renal function using multivariate analysis (multiple regression)

Variables	Regression estimate (B)	SE (B)	*P*
CT	−0.563	0.151	0.0001
Echogenicity	−10.228	2.74	0.0001
CMD	−13.239	1.595	0.0001
Urine pH	−7.968	1.64	0.0001
Pre-PCN creatinine	0.666	0.250	0.009
Status of opposite kidney	3.297	1.528	0.032

CMD: Corticomedullary differentiation, CT: Cortical thickness, PCN: Percutaneous nephrostomy, SE: Standard error

function recoverability. In the present study, we tried to avoid the limitations of univariate analysis by also including the multivariate analysis and have included other factors.

In our study, result demonstrated that CT, parenchymal echogenicity, CMD, pre-PCN creatinine, and status of contralateral kidney are the only independent variables which can predict the renal function while other variables like renal size, urine output, infection, degree of hydronephrosis although having significant influence on renal function lost their statistical significance in multivariate analysis.

Outcome of our study has shown that if these parameters are met then PCN should not be done in the hope of recovering renal function particularly in adult patients. Our study aimed to prevent unnecessary PCN procedure, proper assessment can greatly assist in deciding PCN role in obstructive uropathy and post-PCN renal function. Similar study was done by Ramanathan *et al.*[8] who saw that PCN and proper assessment of renal function may reduce the number of patient procedures overall.

LIMITATIONS

We could not compare the GFR of draining kidney in pre-PCN period, and thus, we have to rely on post-PCN

diff. %CrCl for defining renal function recoverability. There is a lack of long-term follow-up of such patients after the operative procedure. Thus, further study is surely needed in this direction.

CONCLUSION

Percutaneous nephrostomy is a procedure that has significant implications for the treatment of obstruction in the kidneys. However, there have been many instances of the procedure performed unnecessarily. Thus, significant independent predictors like renal CT, CMD, echogenicity, pre-PCN creatinine along with IPP can provide an index to evaluate residual renal function before deciding to perform PCN procedures.

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