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A prospective study on the outcome of pyonephrosis and infected hydronephrosis drained by percutaneous nephrostomy – a tertiary care centre experience

Krishnendu Maiti[1], Souvik Maity[1], Archismita Santra[2], Debansu Sarkar[1]

[1]Department of Urology, Institute of Post-Graduate Medical Education and Research and Seth Sukhlal Karnani Memorial Hospital, West Bengal, India
[2]Department Community Medicine, Employees State Insurance-Post Graduate Institute of Medical Sciences and Research & Employees State Insurance Corporation Medical College and Hospital, West Bengal, India

ABSTRACT

Objective: Pyonephrosis is defined as accumulation of purulent debris in the renal pelvis and urinary collecting system. Urinary diversion through percutaneous nephrostomy (PCN) is the first choice of treatment for pyonephrosis. Even after PCN insertion some patients end up with complete loss of renal function. We aim to determine the proportion of patients undergoing complete loss of renal function after PCN insertion, the factors facilitating renal function recoverability and the complications of the procedure.

Material and Methods: In this prospective observational study, 100 patients with pyonephrosis were consecutively included over a period of one year. Pre-PCN and post-PCN creatinine clearance (CrCL) were analysed. Associated clinical factors were collected on a data sheet proforma. Data were analysed using Stata 12.1.

Results: Mean age of study participants was 44.4 years (standard deviation: 11.8) where majority (69%) were males. Rate of nephrectomy after pyonephrosis was 15.6%. Among the participants, 77% patients did not have any complications after PCN insertion while 18% had dislodgement and 5% had bleeding. Significant improvement was found in post-PCN CrCL compared to pre-PCN CrCL (p-value: 0.001). Persons having severe hydronephrosis had lower odds of having improved glomerular filtration rate after PCN insertion (adjusted odd's ratio 0.3, p-value: 0.005, 95% confidence interval: 0.1-0.7) compared to those having moderate hydronephrosis.

Conclusion: Early PCN insertion is imperative for salvaging a pyonephrotic kidney. It is cost-effective and allows the patient to undergo definitive endourologic surgery for underlying pathology, thus avoiding a potential nephrectomy

Keywords: Pyonephrosis, obstructive uropathy, nephrostomy, urosepsis, hydronephrosis, PCN

INTRODUCTION

Infected hydronephrosis (HN) is defined as a bacterial infection of a hydronephrotic kidney. Pyonephrosis is defined as infected HN associated with suppurative destruction of the renal parenchyma and total or near-total loss of renal function (1). Obstructive pyonephrosis is an acute emergency that can lead to the rapid development of urosepsis and even septic shock, potentially resulting in mortality (2). Early decompression of the collecting system is the most important step in managing pyonephrosis. Urinary diversion can be achieved through percutaneous nephrostomy (PCN) or retrograde ureteral stenting. Although there is no clear consensus regarding the superiority of either method, PCN insertion has become the procedure of choice for draining pyonephrotic kidneys (3,4). However, urinary diversion does not always lead to renal function recovery even after definite treatment of underlying pathological processes. This may be due to other simultaneously occurring pathological processes like interstitial fibrosis and cell apoptosis (5). In this study, we aimed to assess the efficacy of PCN in the management of patients with pyonephrosis and its associated morbidities. Our primary objective was to determine the proportion of patients undergoing nephrectomy after PCN placement. We have also determined the proportion of patients demonstrating improvement in renal function post-PCN insertion, the factors associated with improvement in creatinine clearance (CrCL), after PCN insertion, and examined the intraoperative and postoperative complications of the procedure.

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Corresponding Author
Debansu Sarkar

E-mail: urologyipgmer@gmail.com
ORCID ID: orcid.org/0000-0002-1116-4639

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MATERIAL and METHODS

This was a hospital-based prospective study conducted in a tertiary care hospital in Kolkata from June 2023 to June 2024.

Inclusion Criteria

Patients with pyonephrosis and systemic inflammatory response syndrome (SIRS) attending the Outpatient and Emergency Department of Seth Sukhlal Karnani Memorial Hospital.

Exclusion Criteria

Patients in the infantile age group and patients with coagulopathy.

Methodology

Patients presenting with pyonephrosis with features of the SIRS underwent PCN insertion under local anesthesia. HN was graded according to the Society of Fetal Urology grading system (6,7).

Drain fluid creatinine level was measured on day 1 of PCN insertion. We also measured the total 24-hour urine volume and serum creatinine. CrCL was calculated from drain fluid creatinine using the following formula: CrCL = (UV/P) (1.73/A), where U = creatinine concentration of 24-hour urine volume (mg/dL), V = total volume of urine per minute, i.e., V/1440 mL/min; P = plasma creatinine concentration (mg/dL), A = concentration factor accounting for differences in body surface area as obtained from the height-weight chart.

Similarly, CrCL was measured again, two months post-PCN insertion, from the drain fluid creatinine levels. Patients with low CrCL (<10 mL/min) underwent a diuretic renogram scan for further evaluation of the glomerular filtration rate (GFR) of the affected kidney. Patients with non-functional kidneys (GFR <10 mL/min) were subjected to nephrectomy. Other patients underwent definitive surgery for the underlying pathology.

Sample Size Calculation

According to the study by NG et al. (8) the rate of nephrectomy after pyonephrosis was 12%. Taking the estimated prevalence (p) to be 12% and absolute precision (d) to be 7%, we calculated the sample size (N) using the formula $N = (1.96)2\ pq/d^2$.

Our estimated sample size was calculated to be 82. Considering a dropout rate of 20%, our initially calculated final sample size was 99. In this study, 100 patients meeting the inclusion criteria who visited the hospital during the aforementioned study period were recruited.

Statistical Analysis

Data were analyzed in Stata 12.1 Descriptive statistics were presented as frequency, percentage, mean, and standard deviation (SD). A paired t-test was used to compare initial CrCL and post-PCN CrCL (after 2 months). Univariable logistic regression was done to show the factors associated independently with improvement in CrCL. The variables with a p-value <0.2 in univariable logistic regression were adjusted in multivariable logistic regression. A p-value of less than 0.05 was considered significant in the final adjusted model.

Ethical clearance: Patients were enrolled after obtaining ethical clearance from the Institutional Ethics Committee of IPGME&R, Kolkota (approval number: IPGMER/IEC/2023/434, date: 03.05.2023).

RESULTS

The mean age of study participants was 44.4 years, with a SD of 11.8, and the majority (69%) were males. The majority of the patients (53%) had comorbidities, with diabetes (29%) being the most prevalent. Other recorded comorbidities included hypertension and hypothyroidism. The most common underlying cause was ureteric calculus (35%), followed by pelviureteric junction (PUJ) calculus (23%), vesicoureteral junction stricture at bladder carcinoma (18%), ureteric stricture (13%), and primary PUJ obstruction (PUJO) (11%). Regarding the anatomical site of obstruction, the most common site was at the PUJ (34%), which included obstruction due to PUJ calculus and primary PUJO. The majority (61%) had a moderate degree of HN (grade 2 or 3), while others demonstrated a severe grade of HN (grade 4). The background characteristics of study participants are depicted in Table 1.

Both urine and pus, obtained after pelvicalyceal system puncture, were sent for culture and sensitivity testing. A discordance was observed between organisms isolated from the urine and pus of the same individual. However, in both urine and pus samples, the most common organism isolated was *E. coli* (49% in urine samples vs. 35% in pus samples). Among urine samples, 40% showed no growth of any organism, whereas among pus samples, the proportion was 21%. The distribution of organisms in bladder urine and PCN urine cultures is shown in Figures 1 and 2.

The rate of nephrectomy after PCN insertion in pyonephrosis was 17%. For the remaining patients, we were either able to perform some definitive surgery (74 out of 100) or they were kept on PCN (9 out of 100) in view of morbidity associated with the definitive surgeries. Following PCN insertion, 77% of patients did not experience any complications, while 18% experienced tube dislodgement and 5% had bleeding. The mean pre-PCN CrCL and mean post-PCN CrCL were 17.7 mL/min (SD +8.4) and 21.3 mL/min (SD +9.8), respectively. Using a paired t-test, this improvement was significant (p-value: 0.001, mean difference =1.9). The outcomes of patients post PCN insertion are tabulated in Table 2. In a multivariable logistic regression analysis, persons with severe HN had lower odds of an improvement in GFR after PCN insertion (adjusted odd's ratio 0.3, p=0.005, 95% confidence interval: 0.1-0.7) compared to those having moderate HN (Table 3). Hosmer-

Table 1. Distribution of study participants according to background characteristics (n=100)

Age (years)	Frequency	Percentage
20-39	36	36.0
40-59	52	52.0
≥60	12	12.0
Gender		
Female	31	31.0
Male	69	69.0
Comorbidities		
Diabetes	29	29.0
Hypertension	4	4.0
Diabetes + hypertension	14	14.0
Hypothyroid	6	6.0
None	47	47.0
Diagnosis		
Malignancy related stricture	18	18.0
Ureteric stricture	13	13.0
Nephrolithiasis	23	23.0
PUJ obstruction	11	11.0
Ureteric calculus	35	35.0
Anatomical site of obstruction		
Pelviureteric junction	34	34.0
Upper ureter	26	26.0
Mid ureter	14	14.0
Lower ureter	7	7.0
Vesicoureteric junction	17	17.0
Ureteroileal anastomosis	2	2.0
Degree of hydronephrosis		
Moderate (grade 2 or 3)	61	61.0
Severe	39	39.0

PUJ: Pelviureteric junction.

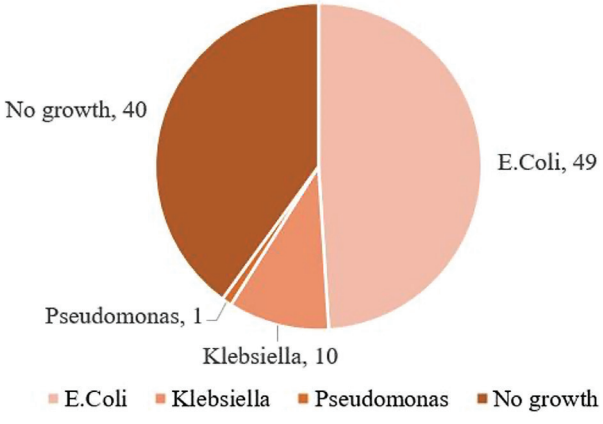

Figure 1. Pie diagrams showing distribution of organsims in bladder urine culture.

Lemeshow goodness-of-fit statistics for the final multivariable logistic regression model were 3.43 with a p-value of 0.49. The adjusted R^2 for the final multivariable regression model was 0.2.

DISCUSSION

In cases of pyonephrosis, PCN has demonstrated several advantages. This procedure is easy to perform under local anesthesia and reduces the bacterial burden by draining pus and necrotic material. This, in turn, decompresses the collecting system, improving renal perfusion and facilitating antibiotic entry into the renal parenchyma to promote better control of sepsis. It also aids in the determination of actual renal function prior to definitive procedures. Direct administration of irrigation fluid and antibiotics is also possible when a PCN catheter is *in situ* (9-11). Although no conclusive evidence of superiority

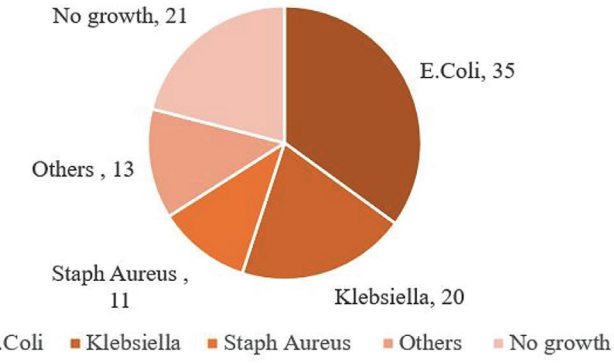

Figure 2. Pie diagrams showing distribution of organsims in PCN urine cultures.

PCN: Percutaneous nephrostomy

Table 2. Distribution of study participants according to outcome after PCN insertion (n=100)

Improvement in creatinine clearance	Number	Percentage
No	34	34.0
Yes	66	66.0
Complications after PCN		
None	74	74.0
Dislodgment	21	21.0
Bleeding	5	5.0
Surgery done		
URSL	33	33.0
TURBT	16	16.0
PCNL	17	17.0
Boari flap	2	2.0
Pyeloplasty	6	6.0
Urinary diversion	9	9.0
Nephrectomy	17	17.0

URSL: Ureteroscopic lithotripsy, TURBT: Transurethral resection of bladder tumour, PCNL: Percutaneous nephrolithotomy.

Table 3. Univariable and multivariable logistic regression showing factors associated with improvement in creatinine clearance among study participants after PCN insertion (n=100)

Independent variables	GFR after PCN insertion		OR (95% CI)	p-value	AOR (95% CI)	p-value	
	Not improved n (%)	Improved n (%)					
Age (in years)							
20-39	12 (33.3)	24 (66.7)	Reference				
40-59	16 (30.8)	36 (69.2)	1.1 (0.5-2.8)	0.8			
≥60	6 (50)	6 (50)	0.5 (0.1-1.8)	0.3			
Gender							
Female	14 (45.2)	17 (54.8)	Reference		2.0 (0.8-5.1)		0.1
Male	20 (29.0)	49 (71.0)	2.0 (0.8-4.8)	0.1			
Comorbidities							
Absent	20 (37.7)	33 (62.3)	Reference				
Present	14 (29.8)	33 (70.2)	1.0 (0.9-1.2)	0.4			
Degree of hydronephrosis							
Moderate	14 (22.95)	47 (77.05)	Reference		**0.3 (0.1-0.7)**		**0.005**
Severe	20 (51.28)	19 (48.72)	**0.3 (0.1-0.7)**	**0.004**			
Diagnosis							
Malignant stricture	6 (33.3)	12 (66.7)	Reference				
Ureteric stricture	6 (46.1)	7 (53.9)	0.6 (0.1-2.5)	0.5			
Nephrolithiasis	8 (34.7)	15 (65.2)	0.9 (0.2-3.4)	0.9			
PUJ obstruction	5 (45.5)	6 (54.5)	0.6 (0.1-2.8)	0.5			
Ureteric calculus	9 (25.7)	26 (74.3)	1.4 (0.4-4.9)	0.6			
Anatomical site of obstruction							
PUJ	13 (38.2)	21 (61.8)	Reference				
Upper ureter	8 (30.8)	18 (69.2)	1.1 (0.1-7.2)	0.8			
Mid ureter	4 (28.6)	10 (71.4)	1.7 (0.1-22.7)	0.7			
Lower ureter	2 (28.6)	5 (71.4)	0.8 (0.1-5.2)	0.8			
Vesicoureteric junction	5 (29.4)	12 (70.6)	0.6 (0.3-11.8)	0.7			
Uretero-intestinal anastomosis	2 (100.0)	0	1.0				

OR: Odd's ratio, AOR: Adjusted odd's ratio, GFR: Glomerular filtration rate, PCN: Percutaneous nephrostomy, PUJ: Pelviureteric junction.

over ureteral stents has been found, PCN has emerged as an initial choice in the management of pyonephrosis. Pearle et al. (12) randomized 42 patients with obstructive uropathy due to ureteric calculus to receive either a PCN or a ureteral stent. There was no difference in outcome parameters [time to resolution of fever or normalization of white blood cell (WBC) count] between the two groups. Stenting was found to be twice as costly as PCN. Ng et al. (8), in a retrospective review of 92 patients, found that the majority of pyonephrotic patients with ureteral obstruction undergoing PCN as interim management were spared open nephrectomy (69% underwent endourologic procedures, 14% open surgeries with 12% nephrectomies, and the remaining 17% had no definitive treatment as the condition resolved or they were unfit). Though no comparisons with ureteral stenting were made, they advised against the routine use of ureteral stents as their smaller sizes can provide less effective drainage, require general anesthesia during the procedure, increase the risk of ureteral perforation during manipulation, and pose a risk of sepsis flare-up due to pressure of irrigation fluid (8). To address the debate regarding the choice between nephrostomy and ureteral stenting, Wang et al. (13) conducted a randomized study comparing the efficacy and safety of ureteral stenting in patients with acute ureteral obstruction and sepsis caused by calculi. They found no difference in time to normalization

of WBC counts and body temperature and comparable complication rates between the two groups. They concluded that if combined with antibiotics, ureteral stenting is safe even in the setting of acute ureteral obstruction with sepsis (13). A cross-sectional study by Kumar et al. (14) among 550 patients with pyelonephritis, 60 of whom had pyonephrosis, found that 44 patients (73.33%) were managed with Double J (DJ) stenting, thus establishing its efficacy and safety in such patients. As of yet, there is no established consensus guiding the choice between PCN and DJ stent in such cases. A clear trend observed among the studies is that earlier studies preferred PCN (8), while more-recent studies show a trend towards the use of DJ stents (13,14). This is probably due to advances and refinements in ureteroscopic instruments and endoscopic techniques. Other factors influencing this choice are cooperation from anesthetists and ready access to operating theatres in high volume tertiary care centres, as was the case of our institute. Nephrostomy is preferred in unstable septic patients (1). Such patients have been excluded from studies supporting DJ stenting. Uncertainties also exist in managing pregnant patients and those with a solitary kidney (13,14).

The review of existing literature has found *E. coli*, to be the most common organism causing retrograde infections in an obstructed kidney (7,8,12,14), a finding further reiterated in our study. We found a disparity between the growth of organisms in bladder urine culture and PCN urine culture. Bladder urine culture was positive in 60% of patients whereas the proportion was 79% for PCN urine culture. In some studies, this disparity between urine and PCN cultures ranges from 27% to 51%. This may be due to antibiotics inhibiting the growth of organisms in the bladder or inhibiting the downward migration of microorganisms to the distal urinary tract due to urinary obstruction. Even if the infection in the lower tract resolves, it may persist in the upper tract due to obstruction. An advantage of PCN is its ability to isolate causative organisms even when bladder urine cultures are sterile, allowing appropriate antibiotics to be instituted (8,15).

Of these patients, 17% underwent nephrectomy. Other procedures performed were laser lithotripsy for ureteric stones, transurethral resection biopsy, urethral stricture surgery, and pyeloplasty. Our rate of nephrectomy was corroborated by other studies [e.g., 10% by Kumar et al. (14), 12% reported by Ng et al. (8)]. However, this rate was much higher in a series of earlier studies, ranging from 35% to 88%, which suggested that nephrostomy followed by nephrectomy was associated with greater operative difficulties and subsequent complications (15-18). This operative difficulty is due to periureteritis and inflammatory perinephric adhesions formed secondary to obstructive uropathy (Figure 3). Recent studies do not support this earlier theory. The improvement in renal function post-PCN may be due to improved renal perfusion, which facilitates antibiotic entry into the parenchyma, and thus causes a reduction in the bacterial burden. Additionally, renal function can return with the control of sepsis. Although the exact pathogenesis of pyonephrosis has not been extensively studied, obstruction and superimposed bacterial infection are considered the two main etiologic factors. Studies have shown that higher degrees of HN directly correlate with the development of pyonephrosis. This is due to increased intrapelvic pressure, which reduces urine production and predisposes the kidney to retrograde bacterial infections (19). With increasing grades of hydronephrosis, parenchymal thickness of the kidney decreases. The parenchymal thickness in a normal kidney is 15-20 mm. Reduced parenchymal thickness adversely affects the recoverability of renal function post-PCN placement. Some studies have shown that a parenchymal thickness <10 mm is associated with non-recoverability of renal function. Our study corroborated this finding, that patients with severe grades of HN had lower odds of recovering renal function post-PCN insertion. Several other factors, such as age, sex, and hemoglobin level, have been found to affect the recoverability of renal function (5,20,21). Males have been found to have a

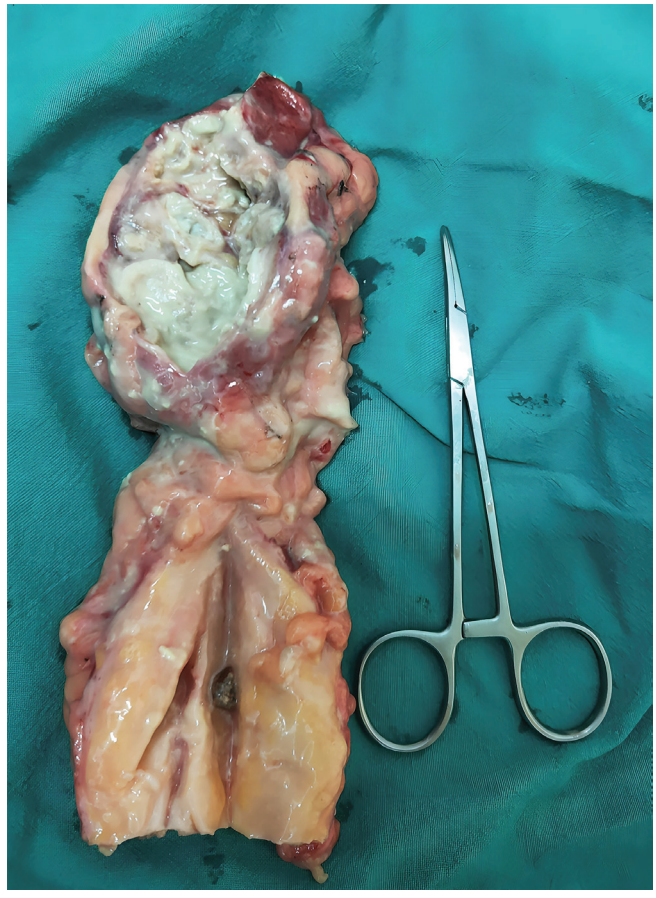

Figure 3. Simple nephrectomy specimen of a pyonephrotic kidney due to a mid-ureteric calculus. Significant intraoperative perinephric adhesions were encountered. Note the thickened walls of ureter secondary to periureteritis caused by obstruction.

more rapid decline in renal function than women due to the protective effect of estrogen (22). These factors were not found to be statistically significant in our study.

However, the Hosmer-Lemeshow goodness-of-fit statistic for the final multivariable logistic regression model was 3.43, with a p-value of 0.49, which indicates that the model fits the data well and predicted probabilities from our model align well with the actual observed outcome. The adjusted R_2 for the final multivariable regression model was 0.2, which indicates that 20% of the variability in the outcome (i.e., improvement in GFR post PCN insertion) is explained by the independent variables included in our model. This is clinically meaningful for decision-making, assessment of prognosis, and patient selection for specific interventions in the context of complex outcomes. Moreover, as human physiology is inherently complex, other factors like genetic predispositions, lifestyle, and individual variability in treatment response may also be responsible for outcome variability, thus highlighting the need for further research in this area.

Study Limitations

However, this study is not without limitations. A study between the two methods of urinary diversion, namely nephrostomy and ureteral stenting, has not been carried out. Whether the type of bacterial pathogens isolated in such patients influences the outcome has not been studied. The state of sepsis was not classified according to APACHE or SOFA scoring. Therefore, whether the severity of sepsis had a role in the non-recoverability of renal function could not be deduced. The timing of symptom onset until decompression can influence the return of renal function. However, in our study, we did not take the starting of symptoms into account as presentations varied. We also excluded the quality of life after PCN, which may influence the choice of urinary diversion.

CONCLUSION

Early PCN insertion is imperative for salvaging a pyonephrotic kidney. It is cost-effective, has minimal anesthesia requirements, is effective in controlling sepsis and promoting subsequent return of renal function. In addition, PCN provides a better yield of bacterial culture, allowing appropriate antibiotic therapy to be instituted. Since the routine insertion of PCN has come into practice, most pyonephrotic cases can now be managed by endourologic procedures, rather than the patient undergoing nephrectomy, as was practiced earlier.

Ethics

Ethics Committee Approval: Patients were enrolled after obtaining ethical clearance from the Institutional Ethics Committee of IPGME&R, Kolkota (approval number: IPGMER/IEC/2023/434, date: 03.05.2023).

Informed Consent: Prospective study.

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Footnotes

Author Contributions

Surgical and Medical Practices - K.M., D.S.; Concept - K.M., S.M., D.S.; Design - K.M., S.M., A.S., D.S.; Data Collection or Processing - A.S., D.S.; Analysis or Interpretation - A.S., D.S.; Literature Search - K.M., S.M., A.S.; Writing - K.M., S.M., A.S., D.S.

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