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Emergency Placed Percutaneous Nephrostomy Catheter Provides Safe and Effective Access for Future Percutaneous Nephrolithotomy Operation

Acil Durumda Yerleştirilen Perkütan Nefrostomi Kateteri Gelecekteki Perkütan Nefrolitotomi Operasyonu İçin Güvenli ve Etkili Erişim Sağlar

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ÖZET

Amaç: Acil durumlarda yerleştirilen perkütan nefrostomi (PCN) kateterinin gelecekteki perkütan nefrolitotomi (PNL) operasyonunda kullanılabilirliğinin araştırılması amaçlandı.

Gereç ve Yöntemler: Ocak 2013 ile Aralık 2018 tarihleri arasında PNL ameliyatı öncesinde acil durumlarda girişimsel radyolog tarafından PCN kateteri takılan hastalar çalışmaya dahil edildi. Demografik özellikler, PCN takılma endikasyonu, taş özellikleri, ameliyat öncesi ve sonrası laboratuvar değerleri, ameliyat sırasındaki veriler, PCN kateterinin renal erişim için kullanılabilirliği/kullanılamazlığı, ameliyat sonrası veriler ve komplikasyonlar kaydedildi.

Bulgular: Çalışmaya toplam 32 hasta dahil edildi. (PCN kullanılabilir: 21, kullanılamaz: 11). Kateter takılma endikasyonu 26 (%81,25) hastada obstrüksiyon, 6 (%18,75) hastada ise idrar yolu enfeksiyonuydu. PNL sırasında 21 (%65,62) hastada PCN kateter yolu kullanılarak renal erişim sağlandı. En yaygın PCN erişimi alt kutuptan kullanıldı. On bir (%34,37) hastada PCN traktı erişim için elverişli değildi. Kaliksin giriş için uygun olmaması nedeniyle PCN'nin kullanılamadığı hastalarda en sık yeni erişim yeri 6 hastada alt kaliks, 3 hastada üst kaliks ve 2 hastada orta kaliks oldu. PCN kateterinin PNL erişimi için kullanılabilir olduğu ve kullanılamadığı iki grup arasında ortalama hastanede kalış süresi dışında (p=0.039) istatistiksel olarak anlamlı fark yoktu (p>0,05).

Sonuç: PNL ameliyatı öncesinde yerleştirilen PCN kateterleri, ameliyat sırasında renal erişim amacıyla etkin ve güvenli bir şekilde kullanılabilir. Ancak acil durumlarda, ileride ameliyat olacak hastalarda PCN kateterinin uygun kaliksten yerleştirilmesi önemlidir.

Anahtar Kelimeler: nefrolitotomi, perkütan nefrostomi, böbrek erişimi, girişimsel radyoloji, taş

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ABSTRACT

Objective: It was aimed to investigate the feasibility of the percutaneous nephrostomy (PCN) catheter placed in an emergency in the future percutaneous nephrolithotomy (PNL) operation.

Material and Methods: Patients who underwent PCN catheter insertion by an interventional radiologist under emergency situations prior to PNL surgery between January 2013 and December 2018 were included in the study. Demographic characteristics, indication for PCN insertion, stone characteristics, pre- and post-operative laboratory values, intra-operative data, usability/non-usability of PCN catheter for renal access, post-operative data and complications were recorded.

Results: A total of 32 patients were included in the study. (PCN usable: 21, unusable: 11). Indications for catheter insertion were obstruction in 26 (81.25%) patients and urinary tract infection in 6 (18.75%) patients. Renal access was achieved in 21 (65.62%) patients by using the PCN catheter tract during PNL. The most common PCN access was used in the inferior pole. In 11 (34.37 %) patients, the PCN tract was not usable for access. In patients in whom PCN was unusable due to an unsuitable calyx for access, the most common new access site was the inferior calyx in 6 patients, the superior calyx in 3 patients and the middle calyx in 2 patients. There was no statistically significant difference between the two groups in which the PCN catheter was usable and unusable for PNL access ($p>0.05$), except for the mean length of hospital stay ($p=0.039$).

Conclusions: PCN catheters inserted prior to PNL surgery can be used effectively and safely for renal access during surgery. However, in emergency cases, it is important that the PCN catheter is inserted through the appropriate calyx in patients undergoing future surgery.

Keywords: nephrolithotomy, percutaneous nephrostomy, renal access, interventional radiology, stone

INTRODUCTION

Percutaneous nephrolithotomy (PNL) is currently the preferred method for the treatment of complex kidney stones larger than 2 cm (1). The most important step of the procedure is to provide appropriate renal access with minimal complications (2). The access is performed intraoperatively by an interventional radiologist or an endourologist depending on the experience of the clinic and the surgeon (3). In addition to intraoperative renal access, PCN catheters previously placed for acute urinary obstruction, pyelonephritis and acute renal failure can be used for renal access.

There are studies in the literature comparing data from patients who had a PCN catheter placed prior to PNL surgery with patients who had renal access during surgery. The availability of a PCN catheter preoperatively may have some advantages, but it may not always be possible to use this tract for renal access (4-6). A limited number of studies have investigated the availability of renal access in patients with previous PCN catheter placement in emergency situations (7-9).

The aim of this study was to investigate the intraoperative usability of the present tract in patients undergoing emergency PCN catheter insertion by the interventional radiologist prior to PNL surgery and the factors influencing this.

MATERIALS AND METHODS

After obtaining approval from the local ethics committee (University of Health Sciences, Bakırkoy Dr. Sadi Konuk Training and Research Hospital, 483 /16 November 2020), patients who underwent PNL surgery between January 2013 and December 2018 at the University of Health Sciences, Bakırkoy Dr. Sadi Konuk Training and Research Hospital were retrospectively reviewed. Patients over 18 years of age who had a preoperative PCN catheter inserted by an interventional radiologist in an emergency situation were included in the study. Patients who had a PCN catheter inserted during PNL and received a catheter for the second session of PNL surgery, patients with planned PCN placement, and patients with missing or irregular study data were excluded from the study. Two patients who had undergone preoperative PCN placement by an interventional radiologist for retrorenal colon, three patients who had retained a catheter for the second session of a previous PNL procedure, and two patients with missing data were excluded from the study. Finally, 32 patients who fulfilled the study criteria were included in the study. Patients were divided into 2 groups, group 1: usable preoperative PCN catheters and group 2: unusable PCN catheters.

Demographic characteristics, pre-operative and post-operative laboratory values, stone characteristics, intra-operative data, indication for PCN catheter insertion, use/non-use of PCN catheter for renal access, post-operative data and complications were recorded. Complications were classified according to the Clavien-Dindo classification system (10).

PCN Catheter Insertion: Under local anesthesia or intravenous sedation, the pelvicalyceal system was entered with an 18 G needle under US and fluoroscopic guidance. After 8F dilatation over the guidewire, a 10F drainage catheter was inserted into the collecting system. All PCN catheters were inserted by an experienced interventional radiologist. Use of PCN catheter: A 5.0F retrograde straight ureteral catheter was placed in all patients except those with transplanted kidneys and skeletal anomalies. The collecting system was opacified by the administration of radiopaque material through the nephrostomy and/or straight ureteral catheter. The sensor guide in the PCN catheter was inserted into the collecting system. After removal of the PCN catheter, access to the renal system was obtained by Amplatz dilation over the guide.

Statistical analysis: Categorical variables were presented as numbers and percentages, and continuous variables were presented as means and standard deviations. The normal distribution of continuous variables was assessed using the Shapiro-Wilk test. The Student t-test was used to compare the means of two independent groups with normal distribution, and the Mann-Whitney U test was used to compare the means of two groups without normal distribution. Pearson chi-square and Fisher's exact test were used to compare the frequencies of categorical variables. $P < 0.05$ was considered statistically significant.

RESULTS

Seventeen patients were male and 15 were female. The mean age was 41.31±17.8 (5-72) years. The mean BMI was 24.6 ± 3.75 kg/m2. Stone location was the left kidney in 14 patients, the right kidney in 16 patients and the right pelvic transplanted kidney in 2 patients. The most common stone location was the renal pelvis. The mean stone size was 2.64 ± 0.82 mm, the mean stone-to-skin distance was 8.65 ± 2.63 cm and the mean Hounsfield unit (HU) was 1101 ± 340 IU. Demographic and stone characteristics of the patients are summarised in Table 1.

Indications for preoperative PCN placement were obstruction (hydronephrosis, acute renal failure) in 26 (81.25%) patients and urinary tract infection (pyelonephritis, pyonephrosis, urosepsis) in 6 (18.75%) patients. The most common preoperative PCN catheter location was the inferior calyx (n: 14, 43.8%). In 21 patients (65.62%) renal access was achieved using the previous PCN tract during PNL (Figure 1.). In two of these patients, the PNL procedure was performed on the transplanted kidney and in one patient on the horseshoe kidney. The average duration of the nephrostomy catheter until the PNL operation was calculated as 10.55 ± 4.65 days. There were 11 patients in whom the previous PCN tract was unsuitable for access. The reasons for the unsuitability of the current tract in these patients were as follows: in 7 patients the calyx was not suitable for stone access (Figure 2), in 2 patients the PCN catheter was placed directly in the renal pelvis, in 1 patient the guidewire could not be advanced due to calcification of the PCN catheter and in 1 patient the PCN tract was not suitable for dilatation due to infundibular access (Table 2). In patients in whom the PCN catheter was unusable due to unsuitability for stone access, the new access site was the inferior calyx in 6 patients, the superior calyx in 3 patients and the middle calyx in 2 patients.

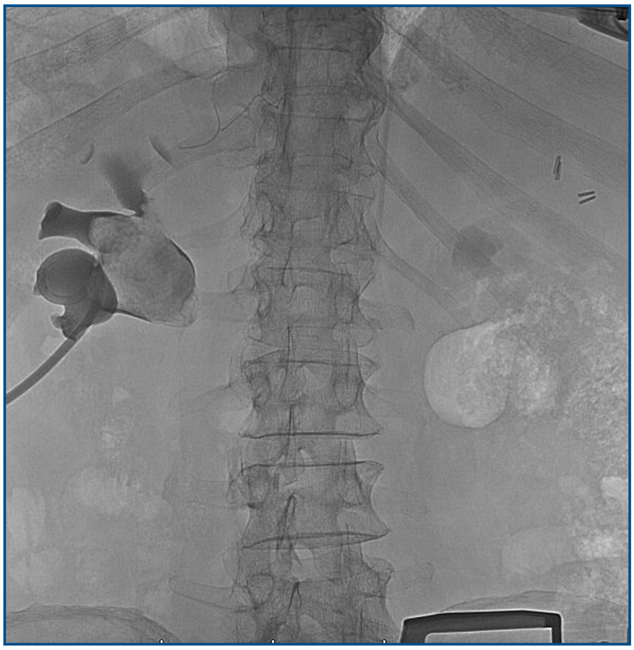

Figure 1. Usable inferior calyx nephrostomy catheter

Figure 2. Unusable superior calyx nephrostomy catheter, new tract created from the inferior calyx

There was no statistically significant difference between the groups in terms of demographics and stone characteristics (p>0.05). There was no statistically significant difference in mean operative time between the two groups (p: 0.979). The mean length of hospital stay was shorter in the nephrostomy catheter tract-usable patient group (3.52 ± 1.12 vs 6.36 ± 4.69, p=0.039). There were Clavien grade 1 complications including transient fever in 2 patients and serum creatinine increase in 1 patient in group 1 and Clavien grade 1 complications including transient fever in 3 patients in group 2. There was one bleeding requiring blood transfusion in group 1 and Clavien grade 2 complications including persistent fever in 3 patients in group 2. Both groups had grade 3 complications requiring postoperative D-J catheter insertion. Although higher complication rates were observed in group 1, there was no statistically significant difference. The postoperative stone-free rate was 71.4% in group 1 and 63.6% in group 2 and there was no statistically significant difference between the groups. Pre- and post-operative data are shown in Table 3.

Table 1. Demographic data and clinical characteristics of the whole study population

Mean age ± SD, (years) Median (IQR)	41.3 ± 17.8 43.5 (5-72)
Mean BMI ± SD, kg/m2 Median (IQR)	24.6 ± 3.75 24.8 (17-35)
Gender, n (%)	
Male	17 (53.1)
Female	15 (46.9)
ASA, n (%)	
ASA 1	9 (28.1)
ASA 2	19 (59.4)
ASA 3	3 (9.4)
ASA 4	1 (3.1)
Comorbidity, n (%)	15 (46.9)

Laterality, n (%)	
Right	16 (50.0)
Left	14 (43.8)
Transplanted Kidney	2 (6.3)
Mean stone diameter ± SD, (cm) Median (IQR)	2.64 ± 0.82 2.55 (1.5-4.2)
Mean stone density ± SD, (HU) Median (IQR)	1101 ± 340 1194 (350-1856)
Mean stone skin distance ± SD, (cm) Median (IQR)	8.65 ± 2.63 8.55 (4.8-14.2)
Indications of PCN, n (%)	
Hydronephrosis (renal colic)	17 (53.1)
Hydronephrosis (AKI)	9 (28.1)
Pyonephrosis	3 (9.4)
Pyelonephritis	2 (6.3)
Urosepsis	1 (3.1)
Mean duration between PCN cathater placement and PNL ± SD, (days) Median (IQR)	26.4 ± 10.9 24 (7-45)
PCN cathater tract location, n (%)	
Pelvis	2 (6.2)
Superior calyx	1 (3.1)
Middle calyx	12 (37.6)
Inferior calyx	17 (53.1)
Usage of prior PCN cathater for PNL, n (%)	21 (65.6)
Location of new PCN for PNL, n (%)	
Superior calyx	3 (21.9)
Middle calyx	2 (3.1)
Inferior calyx	6 (31.3)
Mean preoperative HGB value ± SD, g/dl Median (IQR)	12.6 ± 1.91 12.3 (7.7-16.9)
Mean postoperative HGB value ± SD, g/dl Median (IQR)	11.5 ± 1.69 11.6 (7.4-15.3)
Mean HGB drop ± SD, g/dl Median (IQR)	0.91 ± 0.94 0.70 (0.2-5.4)
Mean surgical time ± SD, (min.) Median (IQR)	105 ± 21.9 105 (65-140)
Complication, n (%)	14 (43.8)
Complications according to CCS, n (%)	
Clavien 1	6 (18.8)
Clavien 2	4 (12.5)
Clavien 3b	4 (12.5)
Mean LOS ± SD, (days) Median (IQR)	4.50 ± 3.13 3 (2-15)
SFR, n (%)	22 (68.8)
Additional treatment after PNL, n (%)	8 (25.0)
Additional treatment after PNL, n (%)	
ESWL	1 (3.1)
URS/RIRS	6 (18.8)
PNL	1 (3.1)
Long term DJS placement	1 (3.1)

SD, standart deviation; IQR, interquantile range; BMI, body mass index; ASA, American society of anaesthesiology score; HU, hounsfield unite; AKI, acute kidney injury; PNL, percutaneous nephrolithotomy; HGB, hemoglobin; CCS, Clavien complication classification; LOS, lenght of hospital stay; SFR, stone free rate; URS, ureteroscopy; RIRS, retrograde intrarenal surgery; DJS, double j stent

Table 2. Reasons for the PCN catheter tract unusable for PNL access

Unusable PCN catheter tract (n)	11
PCN catheter tract unsuitable for stone access	7 (63.7%)
PCN catheter located directly in the renal pelvis	2 (18.1%)
Inability to advance the guide wire due to calcification of the PCN catheter	1 (9.1%)
Unsuitability of the PCN tract for dilatation due to infundibular access	1 (9.1%)

Table 3. Comparison of groups in terms of PCN cathater tract usage as PNL access

Variables	Usable	Unusable	P value
Number of patients	21	11	
Mean age ± SD, (years)	42.5 ± 16.7	38.9 ± 20.5	0.591*
Mean BMI ± SD, kg/m2	25.4 ± 3.72	23.3 ± 3.58	0.133*
Gender, n (%)			0.907#
Male	11 (52.4)	6 (54.5)	
Female	10 (47.6)	5 (45.5)	
ASA, n (%)			0.368&
ASA 1	6 (28.6)	3 (27.3)	
ASA 2	12 (57.1)	7 (63.6)	
ASA 3	3 (14.3)	0 (0)	
ASA 4	0 (0)	1 (9.1)	
Comorbidity, n (%)	12 (57.1)	3 (27.3)	0.108#
Laterality, n (%)			0.864&
Right	9 (42.9)	5 (45.5)	
Left	10 (47.6)	6 (54.5)	
Graft	2 (9.5)	0 (0)	
Mean stone diameter ± SD, (cm)	2.47 ± 0.80	2.97 ± 0.80	0.104*
Mean stone density ± SD, (HU)	1044 ± 384	1209 ± 208	0.211**
Mean stone skin distance ± SD, (cm)	8.84 ± 2.88	8.30 ± 2.17	0.595*
Indications of PCN , n (%)			0.086&
Hydronephrosis (renal colic)	8 (38.1)	9 (81.8)	
Hydronephrosis (AKI)	8 (38.1)	1 (9.1)	
Pyonephrosis	3 (14.3)	0 (0)	
Pyelonephritis	1 (4.8)	1 (9.1)	
Urosepsis	1 (4.8)	0 (0)	
Mean duration between PCN cathater placement and PNL ± SD, (days)	26.4 ±11.5	26.2 ± 10.2	0.961*
PCN cathater tract location, n (%)			0.634&
Pelvis	0 (23.8)	2 (18.2)	
Superior calyx	0 (0)	1 (9.1)	
Middle calyx	8 (38.1)	4 (36.4)	
Inferior calyx	13 (61.9)	4 (36.4)	
Mean postoperative HGB value ± SD, g/dl	10.8 ± 2.82	11.9 ± 1.47	0.249*

Mean perioperative HGB value ± SD, g/dl	1.62 ±1.98	0.77 ± 0.37	0.578**
Mean surgical time ± SD,(min.)	105 ±20.4	105 ±25.8	0.979*
Complication, n(%)	7 (33.3)	7 (50.0)	0.142#
Complications according to CCS, n(%)			
Clavien 1	3 (42.9)	3 (42.9)	
Clavien 2	1 (14.3)	3 (42.9)	0.371&
Clavien 3b	3 (42.9)	1 (14.3)	
Mean LOS ± SD, (days)	3.52 ± 1.12	6.36 ± 4.69	0.039**
SFR, n(%)	15 (71.4)	7 (63.6)	0.703&
Additional treatment after PNL, n (%)	5 (23.8)	4 (36.4)	0.681&
Additional treatment after PNL, n (%)			
ESWL	0 (0)	1 (25.0)	
URS/RIRS	4 (80.0)	2 (50.0)	0.524&
PNL	1 (20.0)	0 (0)	
Long term DJS placement	0 (0)	1 (25.0)	

*Independent sample t test, **Mann whitney U test, #Pearon Chi Square test, &Fisher's Exact test
SD, standard deviation; BMI, body mass index; ASA, American society of anaesthesiology score; HU, hounsfield unite; AKI, acute kidney injury; PNL, percutaneous nephrolithotomy; HGB, hemoglobin; CCS, Clavien complication classification; LOS, lenght of hospital stay; SFR, stone free rate; URS, ureteroscopy; RIRS, retrograde intrarenal surgery; DJS, double j stent

DISCUSSION

Indications for PCN catheter placement include conditions leading to urinary tract obstruction, acute pyelonephritis and their combination (11,12). PCN catheters are usually inserted in emergency situations to provide rapid decompression without definitive treatment. In a recent series published by Sabler et al, only 21 (29%) of 73 PCN catheter routes placed by interventional radiology in emergencies were subsequently used for PNL (9). Cobb et al. argue that most PCN placements performed by interventional radiologists in emergencies are adequate for drainage but not for subsequent PNL (7). In their series of 41 PCN procedures, they reported that only 9 (22%) could be effectively used for PNL. In contrast to these studies, high rates of renal access with PCN catheters have also been reported in the literature. Of 35 PCN catheters placed in emergencies, 18 (51%) were found to be suitable for dilatation and usable for PNL (8). In another study, Tomaszewski et al. showed that 66% (24/38) of PCN catheters placed by interventional radiologists in emergency and non-emergency situations prior to PNL were usable (3). In our study, PCN catheters were used for renal access in 21 (65.62%) patients. Our results show that PCNs placed in an emergency situation can be used safely and effectively, with a high rate of use.

The most common placement of usable PCN catheters is in the inferior pole, with a rate of 56% in the Bradshaw et al. and 47% in the Sabler et al. series (8,9). Considering that the PCN tract is unusable, access other than the upper pole was performed intraoperatively in 53% of cases (8). In the study by Patel et al, it was reported that urologists do not hesitate to use the upper pole, especially for renal access, but the upper pole access may be a concern for the interventional radiologist (13). In our series, only one of the patients with a preoperative PCN catheter had upper pole access. Furthermore, in line with the literature, lower pole PCN catheters were most commonly used for access, similar to the study by Bradshaw et al (8). Furthermore, in our series, in patients in whom the PCN catheter could not be used due to unsuitability for stone access, the new access site was the inferior calyx in 6 patients, the superior calyx in 3 patients and the middle calyx in 2 patients.

One study reported that patients with a PCN catheter definitely required additional percutaneous renal access during PNL (3). Cobb et al. reported in their study that PCN catheters could be used with additional access in 5% of cases and described this as partially usable (7). None of the patients in our series had a partially usable PCN catheter or additional access.

The reasons for the unsuitability of the PCN catheter were reported as pelvic or infundibular placement (30.0%) and suboptimal anatomical placement (70.0%) in the series of Sabler et al. (9). Although there was a high rate of PCN tract suitable for renal access in our series compared to the literature, the current PCN tract was found to be unsuitable in 11 patients and new renal access was required intraoperatively. The reasons for the unsuitability of the current tract in these patients were: unsuitable calyx in 7 patients, pelvic location of the PCN catheter in 2 patients, calcification of the PCN catheter in 1 patient and unsuitability of the PCN tract for dilatation due to infundibular access in 1 patient. Infundibular or direct access to the renal pelvis (14), which is technically difficult and carries a risk of bleeding, was found in a total of 3 patients in our series. The fact that this partially dangerous and not unusable procedure for future percutaneous PCN was less frequent in our series may be attributed to the placement of PCN catheters by a single experienced interventional radiologist.

In the series of Barghouthy et al, the rate of suitability of the previous PCN tract for PNL was reported to be 22% (15). In their series of 23 patients, different renal access was performed in 3 (13%) patients and "re-positioning" was performed in 15 (65%) patients. The authors made an ideal skin incision 5mm from the initial skin incision by passing a guidewire through the PCN catheter. The distal end of the guidewire was moved to the ideal skin incision without changing where the guidewire entered the kidney proximally, resulting in a shorter tract with a better angle. The authors stated that the inappropriate access can be corrected with a repositioning procedure. In our series, no patient using PCN required repositioning.

The advantages of a pre-placed PCN catheter for PNL surgery are that it reduces operative time and may reduce infectious complications following PNL. In a study of PNL patients by Benson et al, operative time was significantly shorter in the preoperative PCN group than in the intraoperative renal access group. It was also reported that the presence of a preoperative PCN significantly reduced post-PNL sepsis. The authors interpreted this as the use of antibiotics appropriate to the culture obtained from the preoperative nephrostomy (5). In contrast, in the study by Chen et al, the presence of preoperative PCN did not significantly contribute to a reduction in operative time (6). In the same study, the PCN catheter did not make a significant difference in terms of complications. Similarly, in another study, the presence of a preoperative PCN did not reduce complication rates or increase the success of PNL (4). In the series by Sabler et al, no statistically significant difference was found, although more complications were observed in patients without a preoperative PCN (9). In our series, there was no difference in terms of operative time and complications. Although the two groups were statistically similar in terms of the number of complications, more transient and persistent fever occurred in group 2. (group 1: two transient fevers, group 2: three transient fevers, three persistent fevers) Considering that the length of stay is prolonged in patients with infective complications, it is understandable that the mean length of stay in group 2 is statistically significantly longer than in group 1.

In our study, unlike other series, the PNL procedure was performed on a transplanted kidney in two patients and on a horseshoe kidney in one patient. It may be advantageous to plan PCN catheter placement with an interventional radiologist, especially in patients with anatomical anomalies such as pelvic, ectopic or transplanted kidneys, in patients with positioning difficulties such as musculoskeletal anomalies, and in patients with a history or prediction of difficult ureteral catheterization. In addition, co-planning of PCN catheter placement in all patient groups by interventional radiologists and urologists with consideration of future definitive surgery will increase the use rate of PCN catheters placed in emergency conditions.

The main limitations of our study are its retrospective design and the small number of patients. Another important limitation is the lack of a control group consisting of patients without a preoperative PCN catheter.

CONCLUSIONS

Renal access is an important step in the PNL procedure. A PCN catheter placed as an emergency in the preoperative period can be used effectively and safely for renal access during surgery. However, if a PCN catheter is planned for all patients, especially specialized patients, it should be placed considering future PNL.

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Informed Consent Statement: Written informed consent was obtained from all the patients for inclusion in this study.

Data Availability Statement: Data is available upon request to corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Author Contributions Conceptualization, K.G.S.,Y.A.,D.N.O. and A.A.; methodology, K.G.S., A.E.S.; software, K.G.S.,Y.A.,A.A.; validation, E.G.; formal analysis, D.N.O.,A.A.; investigation, K.G.S,Y.A.; resources, K.G.S.,Y.A.,D.N.O.; data curation, K.G.S.,Y.A.,A.E.S.; writing—original draft preparation, K.G.S.,D.N.O.; writing—review and editing, K.G.S.,D.N.O,A.A.; visualization, A.E.S,E.G.; supervision, A.E.S,E.G.; project administration, K.G.S.,D.N.O. All authors have read and agreed to the published version of the manuscript."

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