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ORIGINAL ARTICLE

Which factors may effect urinary leakage following percutaneous nephrolithotomy?

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Abstract
Objective To evaluate the factors that may effect urinary leakage following percutaneous nephrolithotomy (PCNL).
Methods Four hundred and thirty-three patients who underwent PCNL were reviewed retrospectively. The factors that may lead to leakage after surgery were analyzed as categorized into four groups according to individual variables (age, sex, body mass index); renal factors (previous surgery, extracorporeal shock wave lithotripsy history, presence of hydronephrosis); stone burden; and surgical features (access number, type of dilatation, presence of nephrostomy catheter). These data were compared for the presence and duration of urinary leakage.
Results There was no statistically significant correlation between individual factors and both the presence of leak (POL) and the duration of leak (DOL) ($P > 0.05$). Among renal factors, only presence and degree of hydronephrosis was significantly correlated with POL ($P < 0.001$) and DOL ($P < 0.001$). The mean cumulative stone burden neither had impact on POL nor correlated with DOL ($P > 0.05$). Among surgical factors, dilatation with a Nephromax dilator significantly increased incidence of POL when compared with an Amplatz dilator ($P < 0.001$), yet did not change DOL. Using an internal ureteral stent significantly decreased incidence of POL and DOL ($P < 0.001$). DOL increased with catheter diameter and stay time ($P < 0.05$).
Conclusion Several yet simple factors appear to be effective in postoperative urine leakage from the access sites after percutaneous stone surgery. Precautions may also be simple if these factors are considered preoperatively.

Keywords Percutaneous nephrolithotomy · Postoperative complications · Risk factors · Urinary leakage

Introduction

Percutaneous nephrolithotomy (PCNL) is a well-established technique for the treatment of urinary stone disease. Bleeding and urine leakage through the percutaneous tract are common events and bothersome to both patients and the surgeon. Nephrostomy catheters in varying diameters are used after standard PCNL operations to provide renal drainage and to tamponade bleeding [1, 2]. Various modifications including the tubeless method have been made in the PCNL techniques and equipments in an attempt to decrease the morbidity of the procedure and increase cost-effectiveness [3]. Nevertheless, urine leakage and bleeding along the nephrostomy tract are still a main concern in PCNL procedures.

In this study, we evaluated the parameters effecting urinary leakage following standard PCNL.

Patients and methods

A total of 433 patients who underwent PCNL performed by multiple surgeons in our department were included in this retrospective study. There were 189 female and 244 male cases with a mean age of 48.1 years (range 13–76).

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Surgical procedure

All percutaneous accesses were performed under general anesthesia and in prone position after retrograde ureteral catheterization. Initial percutaneous access to the selected calyx was performed under C-arm X-ray guidance by using an 18-gauge needle. After entering the collecting system with a guide wire, dilatation was performed with either Amplatz dilators or with the high-pressure balloon dilator Nefromax^{TM} (Boston Scientific) according to surgeon's preference. Regardless of the technique, dilations ended with the placement of a 30F Amplatz sheath (Microvasive, Natick, Massachusetts) through which a 26F rigid nephroscope was inserted. At the end of the operation, the collecting system and ureteral passage were checked with antegrade pyelography. Decision for placing an internal ureteral stent was based on suspect for the presence of mobile residual fragments, prolonged manipulations and when there was an additional intervention involving the ureteropelvic junction. The decision of nephrostomy catheter removal was made according to the color of nephrostomy urine, residual urine volume, and pain status following clamping of the nephrostomy tube unless a re-entry was planned. The patients without urinary leakage were discharged at the same day.

Patients and groups

Patients were categorized into 4 groups with relevance to individual variables, renal factors, stone burden, and surgical features. Individual variables consisted of sex, age, and body mass index (BMI). Renal factors included previous surgery (open or percutaneous nephrolithotomy), extracorporeal shock wave lithotripsy (SWL) history, presence and degree of hydronephrosis. The degree of hydronephrosis was determined by intravenous urography or ultrasonography, as previously described [4]. Kidney stone burden was estimated in terms of square area in millimeters by multiplying the length and the width measured on preoperative plain abdominal radiographs. Surgical features included number of access sites, type of dilatation, size and duration of nephrostomy drainage catheter, presence of ureteral stent, and outcome of surgery. Patients who were immediately dry or with leakage lasting less than 6 h after nephrostomy removal were evaluated in the same group of "absent leakage". This cut-off of 6 h is because it does not cause additional hospital stay permitting discharge on the same day. The presence of leak was determined by wet dressings either reported by the patient or otherwise determined by hourly checking in the ward by a dedicated nurse or resident. The decision for a dry patient is based on patient reported comfort and dry dressing determined by the doctor. All factors were evaluated according to the presence and duration of urinary leakage.

Statistical analyses

For the presence of leak (POL), the Mann–Whitney *U* test, the chi-Square tests, *t* test, and logistic regression analysis, and for the duration of leak (DOL), the Mann–Whitney *U* test, Kruskal–Wallis test, Spearman's rho test and regression analysis were used. A *P* value of <0.05 was considered as statistically significant.

Results

Urinary leakage was detected in 304 of 433 patients (70.2%). The median duration of leakage was 14 h (range 1–200 h). The distribution of cases with and without leakage according to the individual variables, renal factors, and surgical features are shown in Tables 1, 2, and 3, respectively. Also, these tables summarize statistical significances of POL with regard to all defined parameters. Table 4 summarizes statistical significances of DOL.

Individual variables

There was no significant correlation between individual factors and both POL and DOL ($P > 0.05$).

Renal factors

No significant difference was noted in POL and DOL with regard to the presence of previous surgery (open or PCNL) or SWL history ($P < 0.05$). Among renal factors, only the presence and degree of hydronephrosis was significantly correlated with POL ($P < 0.001$) and DOL ($P < 0.001$).

Table 1 Individual parameters according to status of leakage

	Leakage (*n*)		*P* value
	Absent	Present	
Gender (*n*)			
Male	75	169	0.625
Female	54	135	
Total	129	304	
Age (year)			
(*n*)	129	304	0.776
Mean ± SD	48.4 ± 15.7	48 ± 15.5	
Body mass index			
(*n*)	43	130	0.721
Mean ± SD	27.9 ± 5.43	28.3 ± 4.84	

SD standard deviation

Table 2 Renal factors according to leak status

	Leakage (*n*)		*P* value
	Absent	Present	
Surgery history (open or PCNL)			
Negative	86 (30%)	200 (70%)	0.628
Positive	16 (25%)	49 (75%)	
Total	102	249	
SWL history			
Negative	84 (28%)	213 (72%)	0.452
Positive	18 (33%)	36 (67%)	
Total	102	249	
Hydronephrosis grade			
0	41 (45.5%)	49 (54.5%)	0.001
1	44 (27%)	121 (73%)	
2	37 (27%)	102 (73%)	
3	6 (16%)	32 (84%)	
Total	128	304	
Hydronephrosis			
Absent	41 (45.5%)	49 (54.5%)	<0.001
Present	87 (25.5%)	255 (74.5%)	
Total	128	304	

PCNL percutaneous nephrolithotomy, *SWL* shock-wave lithotripsy

Table 3 Surgical factors according to leak status

	Leakage (*n*)		*P* value
	Absent	Present	
Access number			
1	65 (25.7%)	188 (74.3%)	0.234
≥2	26 (32.5%)	54 (67.5%)	
Total	91	242	
Type of dilator			
Nephromax	51 (22.4%)	177 (77.6%)	<0.001
Amplatz	78 (38%)	127 (62%)	
Total	129	304	
J-stent use			
Absent	77 (24%)	241 (76%)	<0.001
Present	52 (45%)	63 (55%)	
Total	129	304	
Treatment outcome			
Failure	4 (28.5%)	10 (71.5%)	0.624
CIRF	41 (27%)	111 (73%)	
Stone free	84 (31.5%)	183 (68.5%)	
Total	129	304	
PCN catheter diameter (Fr)			
<16	5 (8.8%)	52 (91.2%)	0.138
16–26	36 (9.7%)	336 (90.3%)	
PCN catheter stay time (day)			
<3	68 (52.7%)	96 (31.5%)	0.001
≥3	61 (47.3%)	208 (68.5%)	
Total	129	304	

CIRF clinically insignificant residual fragment, *PCN* percutaneous nephrostomy

Stone burden

The median stone burden was 409 mm^2 (range 22–2,700 mm^2) in the leakage-negative group, and 631 mm^2 (range 35–4,000 mm^2) in the leakage-positive group. The mean cumulative stone burden neither had impact on POL ($P = 0.825$) nor correlated with DOL ($P = 0.444$).

Surgical features

The median size of the nephrostomy tubes was 20 Fr (range 14–26), and they were kept in place for a median time of 3 days (range 1–11) postoperatively. Use of a Nefromax dilator appeared to increase the incidence of POL ($P < 0.05$) but did not change DOL ($P > 0.05$). Using a double J-stent significantly decreased POL and DOL ($P < 0.05$). DOL increased parallel to increasing nephrostomy catheter diameter and increasing time to catheter removal ($P < 0.05$). The overall success rate was 96.7%. The outcome of surgery did not change POL and DOL.

According to logistic regression model, urinary leakage was present 2.3 times more with the presence of hydronephrosis (95% CI 1.41–3.98; $P = 0.001$), 1.9 times more with Nefromax dilatation (95% CI 1.26–3.12; $P = 0.003$), and 3.0 times more when a J-stent was not used (95% CI 1.91–4.97; $P < 0.001$).

Regression analysis indicates that one-grade increase in hydronephrosis causes 3.0 times increase in the duration of leakage ($P = 0.006$, standard error (SE) 1.12) and 1-day increase in time to catheter removal cause 3.8 times increase in the duration of leakage ($P < 0.001$, SE 0.79).

Discussion

Percutaneous nephrolithotomy is an integral component in the treatment of larger renal calculi, either as monotherapy or in combination with SWL. Traditionally, 20–24 Fr tube nephrostomy drainage has been advocated after PCNL with the aim of providing reliable urinary drainage, hemostatic tamponade of the percutaneous renal tract and maintaining access for future percutaneous manipulations. Despite these apparent advantages, nephrostomy tubes have been implicated in causing postoperative discomfort and morbidity such as urine leakage and bleeding [1, 2, 5]. Therefore, the practice of routine placement of nephrostomy tube after an uncomplicated PCNL with complete

Table 4 Duration of leakage with regard to all defined parameters

	DOL (h) Median (min–max)	P value
Individual		
Gender		
Male	15 (1–144)	0.924
Female	14 (2–200)	
Age	$r = 0.018$*	0.886
BMI	$r = -0.110$*	0.194
Renal		
Surgery history		
Absent	15 (1–200)	0.625
Open	18.5 (2–96)	
PCNL	18 (6–40)	
SWL history		
Negative	16 (1–200)	0.328
Positive	15.5 (2–68)	
Degree of hydronephrosis	$r = 0.179$*	<0.001
Presence of hydronephrosis		
Absent	18 (2–100)	<0.001
Present	14 (1–200)	
Stone		
Stone burden	$r = -0.039$*	0.444
Surgical		
Access number		
1	12 (2–100)	0.620
≥2	14 (1–200)	
Type of dilatation		
Nefromax	14 (2–200)	0.107
Amplatz	18 (1–168)	
PCN catheter diameter		
<16	11.5 (2–44)	0.002
16–26	16 (1–200)	
PCN catheter stay time (day)	$r = 0.240$*	<0.001
J stent use		
Absent	13 (1–200)	<0.001
Present	18 (2–100)	
Treatment outcome		
Failure	11 (4–44)	0.695
CIRF	14 (1–200)	
Stone free	14 (2–168)	

DOL duration of leak, *BMI* body mass index, *PCNL* percutaneous nephrolithotomy, *SWL* shock wave lithotripsy, *PCN* percutaneous nephrostomy, *CIRF* clinically insignificant residual fragment

* Spearman's rho

stone clearance has been questioned. Recently, there have been several reports in the literature advocating tubeless PCNL [3, 5–7]. Additionally, the size of the nephrostomy tube may also correlated with a degree of postoperative discomfort [8].

As stratified by Lee et al., PCNL has major complications including death, bleeding necessitating intervention and significant infection in 6% of the patients, and minor complications including fever, bleeding necessitating transfusion and prolonged urine drainage from the flank in 50% of the patients [9].

Comorbidities such as renal insufficiency, diabetes, morbid obesity, or cardiopulmonary diseases increase the risk of complications [10]. Faerber and Goh have noted a higher complication rate and longer hospital stay in obese cases when compared to normal weight patients undergoing PCNL [11]. On contrary, other studies have reported that BMI had no impact on the complication rates of PCNL [12, 13]. Our findings are consistent with latter reports as BMI did not effect the presence and duration of urinary leakage after PCNL. Neither gender nor age, the remaining individual variables, had significant effect on urine leak.

Clinical studies have demonstrated that PCNL with standard technique can be performed safely in patients with a history of SWL [14] or open nephrolithotomy [14–16] without increased risk of complications and with success rates similar to that of PCNL in patients with no previous intervention. Our findings indicated too that the presence of previous surgery or SWL treatment had no impact on urinary leak following PCNL.

To our knowledge, the effect of hydronephrosis on post-PCNL access site urinary leakage has not been evaluated before. In the present study, both presence and degree of hydronephrosis were shown to be significantly correlated with urinary leakage. The presence of hydronephrosis not only increased the incidence of leakage but also prolonged its duration parallel to increasing severity of dilatation. One-grade increase in the degree of hydronephrosis caused three times prolongation of access site urinary leakage. It has been reported that reduced parenchymal thickness favors less blood loss. However, the impact on urine leakage has not been addressed [10]. It can only be speculated that thinner parenchyma has lost its compressive, and thus the sealing effect which in turn causes increased urine leak.

Turna et al. have pointed out that the total number of complications rose with increasing stone surface area [17]. In another study, stone size was significantly larger in the stented group because of prolonged urine leakage, and authors have concluded that stone size is predictive for prolonged urine leakage [18]. In the present study, however, there was no significant association between stone burden and urine leak ($P < 0.05$).

Hegarty and Desai have suggested that PCNL utilizing multiple percutaneous tracts is highly effective, and complication rates with such an aggressive approach are comparable to those of PCNL incorporating a single percutaneous tract for more straightforward calculi [19]. Binbay et al. have demonstrated that access number was not predictive factor for prolonged urine leakage development [18]. Our findings were consistent with these results.

Nephrostomy tract dilatation after percutaneous puncture is one of the important steps of percutaneous renal surgery for which rigid dilators or an inflatable balloon are used. Al-Kandari et al. have demonstrated that the acute and chronic renal parenchymal effects of Amplatz or balloon dilators were almost similar [20]. In a clinical study, there was no statistically significant difference with regard to complications between two groups separated according to Nefromax or Amplatz dilation [21]. However, our study revealed a significant difference between Nefromax and Amplatz dilatation groups in terms of urine leak incidence favoring the latter technique for causing less access site urine leakage. Kukreja and coworkers have reported that Amplatz system, with its beveled-edge fascial dilators, is associated with less blood loss since it spreads the renal parenchymal tissue rather than lacerating [10]. This may explain increased urine leak after rapid Nefromax dilation that bears possibility of non-intended tear in parenchymal tissues.

A nephrostomy tube is almost always an adjunct to PCNL and usually a 2–3 Fr smaller tube than the percutaneous tract is used. When a large bore nephrostomy tube is used, prolonged urine leakage after tube removal becomes evident in many patients [8]. Efforts to reduce the morbidity of the procedure and improve postoperative patient comfort include use of smaller drainage catheters. Desai et al. have compared postoperative outcomes among tubeless, conventional large bore (20 Fr) nephrostomy drainage and small bore (9 Fr) nephrostomy drainage following PCNL in a prospective randomized study. They reported the duration of leakage as 21.4 and 13.2 h for large and small bore groups, respectively [5]. Data obtained in the present study paralleled to this finding as the duration of leakage increased with increasing nephrostomy catheter diameter and increasing time to catheter removal ($P < 0.05$). As could be expected, use of a J-stent significantly decreased the incidence and duration of urine leakage, while outcome of surgery had no impact in this regard.

Using small bore catheters and earlier removal appear useful to minimize urine leakage following nephrostomy tube removal after PCNL. And also, Amplatz dilation seems advantageous in this regard.

Conclusions

Several yet simple factors appear to be effective in postoperative urine leakage from the access sites after percutaneous stone surgery. Precautions may also be simple if these factors are considered preoperatively.

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Conflicts of interest None.

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