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ORIGINAL PAPER

Percutaneous nephrolithotomy: keeping the bridge for one night

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Abstract This study was conducted to compare nephrostomy-free percutaneous nephrolithotomy (PCNL) with early nephrostomy tube removal (after 1 day). A prospective study started from January 2008 through December 2009 and included patients who underwent non-complicated PCNL through a single tract without intra-operative residual stones. Nephrostomy-free technique was performed during 2008 (nephrostomy-free group). During 2009, a nephrostomy tube was placed for 1 day (1-day nephrostomy group). Both groups were compared for post-operative events, dose of analgesia, hemoglobin deficit and hospital stay. The study included 55 patients (27 in nephrostomy-free group and 28 in 1-day nephrostomy group). There were no statistically significant differences between patients, renal and stone characteristics of both groups. Post-operative events were significantly more in nephrostomy-free group (26 vs. 14.3%, $p = 0.039$). They include hematuria in three (11.1%) of nephrostomy-free patients and one (3.6%) of 1-day nephrostomy patient, severe renal colic in four patients of nephrostomy-free group (14.8%), and temporary urinary leakage via the nephrostomy site in three patients of 1-day nephrostomy group (10.7%). Mean dose of post-operative analgesia, mean hemoglobin deficit and hospital days were comparable for both groups ($p = 0.946$, 0.541, 0.807, respectively). A second look PCNL was performed through the already present tract to retrieve residual stones in two patients with nephrostomy. In conclusion, 1-day nephrostomy technique after PCNL showed significantly better post-operative course. It was comparable to nephrostomy-free technique in analgesic requirements and hospital stay. The nephrostomy tube provided a bridge for second look nephroscopy.

Keywords Percutaneous nephrolithotomy · Tubeless · Calculi · Renal stones · Nephrostomy

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Introduction

In 1976, Fernstrom and Johansson [1] performed the first percutaneous nephrolithotomy (PCNL) for treatment of renal calculi. Over the following years, the technique was markedly refined together with improved instruments and experience [2]. Currently, it is the first choice for treatment of large, complex and staghorn renal stones [3, 4]. An integral part of the technique was the placement of a nephrostomy tube at the conclusion of the procedure, the aims of which were adequate drainage of the kidney, tamponade of the tract and the ability to perform a second look nephroscopy for residual stones. However, the nephrostomy tube was associated with patients' discomfort and prolonged hospital stay. Therefore, the large sized tube of 16–22 French (F) was replaced with smaller tubes (8–9 F) [5, 6].

The first series of nephrostomy-free PCNL was reported by Bellman et al. [7] in 1997. Following this, several series of tubeless PCNL were reported and the authors concluded that this modification was safe in selected patients and had several advantages such as dry flank, reduced post-operative pain, analgesic requirements, shorter hospital stay and lower cost. These advantages were proved through many randomized controlled trials [8–14]. The main disadvantages of nephrostomy-free technique included affection of the decision to omit placement of the nephrostomy tube by intraoperative events, loss of the tamponade effect of the

nephrostomy tube and losing the tract for second look PCNL in case of residual stones.

Moreover, placement of a nephrostomy tube for 48 h after PCNL is still a common practice in many places even after non-complicated procedure with no residual stones. Therefore, this study was conducted to test the hypothesis that reducing the time of nephrostomy tube to 1 day may decrease the disadvantages of placement of the nephrostomy tube for 2 days (such as increasing the need for analgesia and longer hospital stay). At the same time, the advantages of the nephrostomy tube such as tamponade of the tract and keeping the bridge for doing second look nephroscopy for removal of residual fragments will not be lost.

Patients and methods

This study was prospectively planned for patients with renal stones who will undergo PCNL. After approval by the ethical committee, an informed consent was signed by all patients. The study started at 1 January 2008 and ended at 31 December 2009. Pre-operative exclusion criteria were the patients under anticoagulant or antiplatelet medications, pediatric patients (age <15 years), serum creatinine >2 mg/dl and obstructed infected kidneys. A standard technique of PCNL was performed as previously described [15]. Intraoperative fluoroscopy was used for detection of residual stones. Flexible nephroscopy was used to retrieve calyceal stones away from the tract and to confirm stone-free status. This study included only patients who had undergone non-complicated PCNL via a single tract without intraoperative evidence of residual stones.

During the first year of the study (2008), placement of a nephrostomy tube was omitted for included patients (nephrostomy-free group). Manual compression was applied to the flank for few minutes and the skin puncture was closed with one stitch. A ureteral catheter was left overnight for drainage of the kidney. During the second year (2009), a 22 F nephrostomy tube was placed and clamped for 1–2 h, and then it was opened. The nephrostomy was left in place for 1 day (1-day nephrostomy group).

Non-contrast CT (NCCT) was performed in the first post-operative morning for all patients. The nephrostomy tube was removed after revising the CT images, and then the ureteral catheter was removed when the nephrostomy site was dry. Post-operative analgesic medication was ketoprofen intramuscular injection at a dose of 100 mg per injection.

Both groups were compared for post-operative events, dose of analgesia, hemoglobin deficit, residual stones, hospital stay and incidence of intra-renal or perirenal hematomas diagnosed by NCCT.

Statistical analysis

Statistical analysis was done using Statistical Package for Social Sciences, version 15 (SPSS, Chicago, IL). Categorical variables were compared using Chi-square test and continuous variables were compared using *t*-test. p value <0.05 was considered statistically significant.

Results

The study included 55 patients (27 in nephrostomy-free group and 28 in 1-day nephrostomy group). Patients' demographics, renal and stone characteristics are summarized in Table 1. There were no statistically significant differences between both groups.

Operative details, post-operative events, and results are presented in Table 2. Post-operative events were

Table 1 Comparison of patients, renal and stone characteristics of nephrostomy-free and 1-day nephrostomy groups

Variable	Nephrostomy-free *N* (%)	1-day nephrostomy *N* (%)	*p* value
Gender			
Male	11 (40.7)	16 (57)	0.224
Female	16 (39.3)	12 (43)	
Side			
Right	17 (63.3)	19 (68)	0.703
Left	10 (37)	9 (32)	
Renal morphology			
Hydronephrosis	18 (66.7)	23 (82)	0.724
Normal	6 (22.2)	3 (11)	
Pyelonephretic	3 (11.1)	2 (7)	
Solitary kidney	3 (11.4)	4 (14.3)	0.724
Previous stone surgery	10 (37)	13 (46.4)	0.480
Stone burden			
Single	18 (66.7)	16 (57.1)	0.768
Multiple	6 (22.2)	8 (28.6)	
Staghorn	3 (11.1)	4 (14.3)	
Stone sites			
Renal pelvis	12 (44.4)	9 (32.1)	0.861
Calyceal	2 (7.4)	3 (10.7)	
Pelvis and calyceal	10 (37)	13 (46.5)	
Upper ureter	3 (11.1)	3 (10.7)	
Urinary tract infection	10 (37)	7 (25)	0.334
Age (years)[a]	53.6 (10.8)	50.4 (13.4)	0.335
BMI (kg/m^2)[a]	32.4 (7.1)	30.4 (5.9)	0.390
Stone surface area (mm^2)[a]	342 (265)	398 (293)	0.460

[a] Mean (SD)

N number of patients

Table 2 Comparison of operative and post-operative data of nephrostomy-free and 1-day nephrostomy groups

Variable	Nephrostomy-free *N* (%)	1-day nephrostomy *N* (%)	*p* value
Skin puncture			
Subcostal	20 (74.1)	16 (57)	0.187
Supracostal	7 (25.9)	12 (43)	
Calyx puncture			
Lower	17 (63)	14 (50)	0.619
Middle	4 (14.80)	6 (21.4)	
Upper	6 (22.2)	8 (28.6)	
Post-operative course			
Uneventful	20 (74.1)	24 (85.7)	0.039
Hematuria	3 (11.1)	1 (3.6)	
Severe colic	4 (14.8)	0 (0)	
Urinary leakage	0 (0)	3 (10.7)	
Post-operative CT			
Free	17 (63)	21 (77.8)	0.110
Hematoma	10 (37)	5 (18)	
Intra-renal hematoma	7 (25.9)	3 (11.1)	0.161
Perirenal hematoma	3 (11.1)	2 (7.1)	
Stone-free	25 (92.6)	27 (96.4)	0.531
HB deficit (g/dl)[a]	1.1 (0.9)	0.9 (0.5)	0.541
Hospital days[a]	2.37 (0.8)	2.43 (0.9)	0.807
Analgesic dose[a]	155 (85)	157 (88)	0.946

[a] Mean (SD)

N number of patients

significantly more in nephrostomy-free group (26 vs. 14.3%, $p = 0.039$, Table 2). Post-operative significant hematuria requiring blood transfusion developed in 3 patients (11.1%) of nephrostomy-free group and one patient (3.6%) of 1-day nephrostomy group ($p = 0.282$). They were successfully managed by bed rest, hemostatic drugs, and one unit of blood transfusion for each patient. The nephrostomy tube was clamped for 24 h in the patient of 1-day nephrostomy group. Hospital discharge was postponed till stoppage of the hematuria. Hospital stay for the 3 patients of nephrostomy-free group was 3, 4 and 6 days while it was 6 days for the patient in 1-day nephrostomy group.

Post-operative severe renal colic, requiring more injection of analgesia and resulting in prolongation of the hospital stay for an extra day, was experienced by four patients in nephrostomy-free group (14.8%). None of the patients in nephrostomy-free group developed urinary leakage via the nephrostomy site. On the other hand, none of the patients in 1-day nephrostomy group developed post-operative severe renal colic but temporary urinary leakage via the nephrostomy site was observed in three patients (10.7%). This resulted in prolongation of the hospital stay for one extra day in two patients and two more days in the remaining patient till the leakage stopped spontaneously.

NCCT showed more hematomas in nephrostomy-free patients (37 vs. 18%, $p = 0.110$) and this was the result of increased incidence of intra-renal hematomas (Table 2). Mean dose of post-operative analgesia, mean hemoglobin deficit and hospital days were comparable for both groups ($p = 0.946$, 0.541, 0.807, respectively, Table 2).

A second look PCNL was performed through the already present tract to retrieve residual stones for two patients in 1-day nephrostomy group. Ureteroscopy was performed in one patient among nephrostomy-free group to remove a stone fragment that passed to the ureter causing severe renal colic. Stone-free rate were comparable in both groups (92.6% in nephrostomy-free group vs. 96.4% in 1-day nephrostomy group, $p = 0.531$). Small residual stones (<4 mm) were followed without active intervention in two nephrostomy-free patients and one patient in the 1-day nephrostomy group.

Discussion

Since the introduction of PCNL for treatment of renal stones, placement of a nephrostomy tube was a routine step at the conclusion of the procedure. It served for drainage of the kidney, hemostasis of the tract and allowed for second look nephroscopy to treat residual stones through the already present tract. This concept was augmented after the report of Winfield et al. [16], who described two complications of early removal of the nephrostomy tube namely severe bleeding and extensive urinary extravasation. On the other hand, a nephrostomy tube was associated with patients' discomfort and prolonged hospital stay. These were the main reasons to use a small nephrostomy tube or to omit the placement of it in the so called "tubeless" PCNL [6, 7]. We think that the term "tubeless" is misleading because in many series the kidney was drained with either internalized or externalized ureteral stents [7, 17]. Therefore, we prefer the term nephrostomy-free PCNL except in the few reports where no tubes were placed [18].

In the standard PCNL, a post-operative radiological study (KUB or nephrostography) is usually done after 48 h to give time for resolution of bowel distension and clearance of hematuria. Reducing the period of nephrostomy tube will theoretically reduce patients' discomfort and shorten the hospital stay. Other advantages of shorting the nephrostomy period (1 day) include compressing the tract immediately after surgery to reduce tract bleeding, and use of this tract for a repeat procedure for retrieval of residual stones [19].

The first modification that was applied by Mishra et al. [19] and in our series was the use of a ureteral catheter instead of a double-J stent. The advantages of using a ureteral catheter include reduction of stent-related morbidity and avoidance of an extra endoscopic procedure for removal of the double-J and reduction of the total cost. The second modification was the use of NCCT on the first day after surgery because CT is not affected by bowel status, it is more sensitive than KUB for detection of residual stones, and it is more sensitive for diagnosing complications and hematomas.

The wisdom of tubeless PCNL was questioned by Mishra et al. [19], in a randomized controlled study. They showed that; with these modifications; the advantages of tubeless PCNL were not significantly different from early tube removal. In our study, we challenged the advantages of nephrostomy-free PCNL by reducing the period of the nephrostomy tube to 1 day. This had resulted in decreasing the need for post-operative analgesia in addition to shorting of the hospital stay to be comparable to that of the nephrostomy-free patients. Health care policies are not the same for every country. In many places allover the world (including ours), the patient remained hospitalized for at least 1 day after PCNL. Therefore, keeping the nephrostomy tube until the next morning will not add burden to hospital resources.

At the same time, we had confirmed that leaving a nephrostomy tube overnight was advantageous in reducing the incidence of intra-renal hematoma and post-operative events. Another advantage of leaving a nephrostomy tube was the use of the already present tract to retrieve residual stone detected by post-operative NCCT in two patients although on-table fluoroscopy was free of residuals.

Nephrostomy-free PCNL was reported in different stone burdens; including staghorn stones [20], different patients characters; including obese patients [21], different renal characters; including solitary kidney [22] and different percutaneous access; including supracostal tracts [23]. In the present series, multiple, staghorn, recurrent, radiolucent stones, calculi in a solitary kidney and obese patients were included in the study. However, for proper comparison we excluded patients who developed complications such as significant bleeding or perforation and those with intraoperative significant residuals. In these conditions, omitting the nephrostomy placement seems dangerous or not acceptable as intraoperative events should judge the final decision of leaving a nephrostomy or not. This is another advantage of leaving a nephrostomy tube after PCNL because it is applicable whatever the intraoperative events.

The main limitation of our study was non-randomization of patients between treatment groups. We tried to minimize the effects of non-randomization by including all eligible consecutive patients during the first year of the study in nephrostomy-free group and during the second year in 1-day nephrostomy group. Moreover, statistical analysis showed that there were no significant differences of patients, renal and stone characteristics between both groups.

A peculiar post-operative event was observed for each group. In the nephrostomy-free; it was severe post-operative renal colic in 15% of patients that resulted in prolongation of hospitalization and use of more analgesia. This colic was attributed to passage of blood clots in three patients because the colic disappeared after passage of these clots. In one patient the colic was due to slippage of a residual stone to the ureter and it was treated by ureteroscopic retrieval of this residual. This complication was not seen in patients with nephrostomy tube because most of the blood clots in the collecting system were allowed to pass through the nephrostomy tube and presence of the nephrostomy encouraged second look PCNL for residual fragments.

On the other hand, the peculiar post-operative event of patients with nephrostomy tube was transient leakage from the nephrostomy site in 10.7% of patients. This leakage was not encountered in any patients in the nephrostomy-free group in spite of temporary ureteral obstruction by blood clots or slipped residual stone. It was reported by Mishra et al. [19] that the duration of urine leakage was statistically less in the tubeless group.

Mishra et al. [19] had found that the incidence of early hematuria and collections were less and stone clearance rates were greater in patients with nephrostomy tube. In our patients, the incidence of post-operative events such as hematuria and colic was significantly more in nephrostomy-free patients. Also the incidence of intra-renal hematoma was more in those patients, but the difference was not statistically significant ($p = 0.161$). For the stone-free rates we found better results with 1-day nephrostomy group, but the difference was also not statistically significant ($p = 0.531$). This can be explained by difference in number of patients in our study (55 patients) compared with 22 patients in the Mishra study and exhaustion of all intra-operative methods (fluoroscopy and flexible nephroscopy) to confirm the stone-free status in our study. Therefore, a large scale randomized controlled study is needed to confirm these results.

After review of all literature of nephrostomy-free PCNL, Zilberman et al. [24] concluded that the default decision should be not to insert a nephrostomy tube unless intraoperative findings or complications warrant tube placement. Nevertheless, the decision should be individualized, based on surgeon experience and judgment. They considered six indications for nephrostomy tube placement: (1) more than two access tracts, (2) significant perforation of the collecting system, (3) the need for second look

nephroscopy, (4) significant intraoperative bleeding, (5) complicated procedure and (6) chance of intrathoracic violation. Then they listed in the appendix other possible circumstances in favor of nephrostomy tube placement such as prolonged surgical procedure, coagulopathies, obstructed kidney, anatomical renal anomalies, abnormal renal function, bilateral procedure, American Society of Anesthesiologists score greater than 2, age younger than 15 or older than 60 years. On contrary, our results and that of Mishra et al. [19] had confirmed that any patient who is clinically and intraoperatively fit for a tubeless procedure is also fit for early tube removal with comparable outcomes regarding analgesic requirement and hospital stay and better post-operative course in the patients with 1-day nephrostomy. Moreover, 1-day nephrostomy approach can also be used for most patients and circumstances that preclude tubeless PCNL.

Conclusions

One-day nephrostomy technique after PCNL showed significantly better post-operative course. It was comparable to nephrostomy-free technique in analgesic requirements and hospital stay. The nephrostomy tube provided a bridge for second look nephroscopy.

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