

# Are we fearful of tubeless percutaneous nephrolithotomy? Assessing the need for tube drainage following percutaneous nephrolithotomy

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## Abstract

**Objective:** The objective was to demonstrate that percutaneous nephrolithotomy (PCNL) can be safely performed with a tubeless or totally tubeless drainage technique.

**Introduction:** Standard PCNL includes nephrostomy tube placement designed to drain the kidney and operative tract at the conclusion of the procedure. Modern technique trend is tubeless PCNL and totally tubeless PCNL, which are performed without standard nephrostomy drainage. We aim to reinforce current literature in demonstrating that PCNL can be safely performed using a tubeless technique. With compounded supportive data, we can help generate a trend toward a more cost-effective procedure with improved pain profiles and patient satisfaction, as previously shown with the tubeless technique.

**Methods:** Retrospective analysis of 165 patients who underwent PCNL treatment was performed. Of this group, 127 patients underwent traditional nephrostomy drainage following PCNL. A tubeless procedure was performed in the remaining 38 patients. Patient's postoperative stone size and burden as well as complication profiles were analyzed. Largest stone size and total stone burden was similar between the groups.

**Results:** Patient characteristics and demographic information were compared and no significant statistical difference was identified between the groups. Complication rates between the groups were compared and no statistical difference was noted. A total of 23 patients had at least one postoperative complication.

**Conclusion:** Tubeless and totally tubeless PCNL demonstrates equivalent outcomes in the properly selected patient group when compared to PCNL performed with a nephrostomy tube. Although this is not the first study to demonstrate this, a large majority of urologists continue standard nephrostomy placement after PCNL. More studies are needed that demonstrate safety of this practice to shift the pendulum of care. Thus, tubeless and totally tubeless PCNL can be performed safely and effectively, which has previously been shown to improve cost, patient pain profiles, and length of hospitalization.

**Key Words:** Calculi, endoscopic surgical procedure, nephrolithotomy, percutaneous nephrostomy

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**Received:** 16.04.2015, **Accepted:** 04.05.2015

Access this article online	
Quick Response Code:	Website: www.urologyannals.com
	DOI: 10.4103/0974-7796.162214

## INTRODUCTION

Since its first description in 1976 by Fernström and Johansson,<sup>[1]</sup> percutaneous nephrolithotomy (PCNL) has developed into a mainstream urologic approach for management of large renal stones.<sup>[2]</sup> Today, the standard approach to PCNL includes placement of a nephrostomy tube designed to drain the kidney and tract created during

the procedure. The rationale for nephrostomy tube placement was derived primarily from the 1986 study performed by Winfield *et al.* This report described two PCNL cases with postoperative complications of “premature nephrostomy tube removal” that potentially could have been prevented with continued renal drainage, and one case actually requiring placement of a percutaneous nephrostomy tube as treatment.<sup>[3]</sup> This case series ( $n = 2$ ) challenged the previously accepted view that PCNL without postoperative drainage could be performed safely and without the development significant complications.<sup>[4]</sup> Winfield’s 1986 report evoked a movement within the urologic community to include nephrostomy drainage with percutaneous stone treatment. Since adopting this “standard,” most urologists currently continue its practice, instilled within urologic training, and continue to perpetuate the notion that percutaneous drainage following PCNL is a requirement.

Stent and drainage-tube related pain is one of the most common urologic complaints in the operative patient. Modern techniques have begun to re-explore the idea of PCNL without standard nephrostomy drainage. “Tubeless PCNL” refers to internal drainage by use of a ureteral stent without nephrostomy tube placement postprocedure. Several studies have demonstrated the safety and efficacy of this approach.<sup>[2,5-12]</sup> An even newer approach, “totally tubeless PCNL” refers to PCNL performed without the placement of a ureteral stent or nephrostomy tube. This “totally tubeless PCNL” technique has been shown to be a reasonable approach with proper patient selection.<sup>[6,13,14]</sup> A prospective randomized controlled study with a total of 131 patients demonstrated that the length of hospital stay, pain profiles, and use of analgesics was significantly lowered in patients undergoing the totally tubeless PCNL technique.<sup>[13]</sup>

Over the past two decades, many advances in medicine and surgery have transpired which allows procedures once deemed as requiring inpatient hospital stay now can be performed in an outpatient setting. In the case of PCNL, the best way to move toward an outpatient setting would be to demonstrate the safety and efficacy of a tubeless or totally tubeless approach. Outpatient PCNL may prove to be the most cost effective manner to treat a variety of stones presently treated in a staged manner using other endourologic techniques in addition to large renal stones for which PCNL indication currently exists.

## METHODS

Medical records from patients who underwent PCNL at our tertiary care academic institution over a 30-month period from 2010 to 2012 were reviewed. All patients included in this study

were treated with PCNL by a single surgeon. Parameters for determining which patients were best suited for tubeless or totally tubeless PCNL were developed based on the current literature [Table 1]. Patients were excluded if these criteria were not met, or if they had a more complex presentation with secondary medical conditions. We excluded patients with large staghorn stones, spine bifida, urinary diversion, hemophilia, polio, quadriplegia/paraplegia, and cerebral palsy.

After performing a retrospective review of patient charts and radiographic images, 165 patients were established as appropriate candidates for a tubeless or totally tubeless procedure based upon the predetermined criteria [Table 1]. The type of renal drainage was identified for each patient categorizing him or her into a different arm of the study [Table 2]. Of this group, 127 patients underwent “traditional” drainage following PCNL that included nephrostomy drainage (typically 16Fr) with either a nephrostomy tube alone ( $n = 73$ ) or a nephrostomy tube and stent ( $n = 54$ ). The remaining 38 patients had either a tubeless procedure ( $n = 26$ ) with placement of only a ureteral stent (typically 6Fr) without any percutaneous drain or totally tubeless ( $n = 12$ ) procedure complete with no form of renal drainage.

Data for all patients within the study was thoroughly collected. Electronic and paper-based documents including office charts, hospital records, operative records, and radiographic images were retrieved and data were extrapolated. Patient demographics, pre- and post-operative imaging, and laboratory data were collected. Operative details including site of renal

**Table 1: Patient selection criteria indicating patients appropriate for either the tubeless or totally tubeless PCNL procedure**

Stone size (per CT)	<20 mm
Creatinine	Normal range
Solitary kidney	Not present
UTI	Treated or not present
Certain comorbidities	
Large staghorn stones	Not present
Spine bifida	
Urinary diversion	
Hemophilia	
Polio	
Quadriplegia/paraplegia	
Cerebral palsy	
Operative time	<120 min
EBL	<100 cc
Major collecting system tear	Not present

CT: Computed tomography, UTI: Urinary tract infection, EBL: Estimated blood loss, PCNL: Percutaneous nephrolithotomy

**Table 2: Post-PCNL drainage of 165 qualifying patients**

Drainage technique	Frequency	Percentage
Nephrostomy tube	73	44.2
Nephrostomy tube and ureteral stent	54	32.7
Tubeless (ureteral stent only)	26	15.8
Totally tubeless (no drainage tubes)	12	7.3

PCNL: Percutaneous nephrolithotomy

access and access approach, stone location and size, intravenous fluids used, estimated blood loss, presence/absence of collecting system tear identified during renal endoscopy or nephrogram, operative time, fluoroscopy time, and size and type of drainage tube if placed. Chemical composition of stones was documented. Length of postoperative hospital stay and emergency room readmission rates were documented. Patient complication profiles were constructed from records including whether the following complications were present: Fever, nausea/vomiting, ileus, blood transfusion, wound infection, urinary tract infection (UTI), pleural effusion, pneumonia, pneumothorax, pulmonary complications of dyspnea/hypoxia, pulmonary embolus, respiratory failure, deep vein thrombosis, angina, cardiac changes, MI, seroma, hematoma, urinoma, bacteremia, sepsis or death. Stone size and total stone burden was documented. Total stone free rate (SFR) was determined under the strictest criteria permitting no residual stone fragments. Clinical SFR was defined as residual stone fragments <3 mm. Residual stone was determined by evaluating preoperative computed tomography (CT) and postoperative kidney ureter bladder (KUB) or CT images, based upon radio-opacity demonstrated in preoperative scout films.

Data were entered into a Microsoft database in accordance with HIPPA and IRB. Analysis was then performed using this relational database by a team of analytic statisticians using descriptive statistics and univariate analysis. The categorical variables were compared using Chi-square/Fisher's exact test as appropriate and continuous variables were compared using two sample *t*-test between groups. Data were analyzed using SAS Institute Inc. 2008. SAS/STAT<sup>®</sup> 9.2, 100 SAS Campus Drive, Cary, NC 27513-2414, USA and all *P* < 0.05 were considered statistically significant.

### Percutaneous nephrolithotomy procedure

Surgical procedure is standardly initiated with a systematic extensive review of the CT in multiple axis in determining the best calyx for "on-target" access, optimal angle of entry, distance from skin to renal parenchyma, system and stone, and identifying a "safe zone of entry" from the posterior. The scout films were also used to identify if the calculi were radio-opaque or radiolucent and this would determine which imaging modality (KUB or CT) would be acceptable in following these patients postprocedure. The surgical technique performed was the standard prone approach, as described by Vicentini *et al.* with renal access and all steps of the procedure performed by the urologist.<sup>[15]</sup>

In conclusion, the collecting system is carefully examined with endoscopy and fluoroscopy. Any evidence of significant injury to the collecting system is an indication for placement

of a nephrostomy tube for adequate drainage. A nephrogram identifies collecting system integrity. Medial extravasation of contrast represents significant injury to the collecting system (usually disruption of the pelvis or major calyx) indicating nephrostomy tube placement. Lastly, manual pressure was applied to the incision site. After 3–5 min of pressure, the renal access tract was examined for any visual evidence of bleeding before removal of the safety wires. Significant bleeding from the access tract is assumed to be hemorrhage from the renal parenchyma, and would indicate the need for nephrostomy drainage.

### RESULTS

Patient demographic information (including age, body mass index, and prior history of lithotripsy or endoscopy) and comorbidities were compared. There was no significant statistical difference identified between the four post-PCNL drainage techniques (*P* > 0.05) regarding demographical and comorbidities [Table 3]. It should be noted that previous PCNL procedure on the same kidney was disproportionately higher in the patients who underwent nephrostomy drainage. Largest stone size and total stone burden, also demonstrated in [Table 3], was similar between the groups as well. In cases with multiple stones peroperative side, maximum stone size was used to characterize patient. No significant changes were found between the groups in terms of operative time, fluoroscopy time, or blood loss.

Stone free rates were calculated to show procedure effectiveness within this select patient cohort [Table 4]. SFR was determined under strict criteria permitting no residual stone fragments in complete SFR and <3 mm in clinical SFR; these numbers did not incorporate any adjunct procedures for stone clearance. Following a patient with KUB was only permitted if thought to be stone free during intra-operative endoscopic evaluation and proven radiopacity of initial stone burden based on preoperative scout images. We demonstrated a complete SFR of 81% and a clinical SFR of 84%. Direct comparison of postoperative creatinine changes showed no difference between the varying drainage techniques [Graph 1]. A total of 23 patients had at least one postoperative complication, which was comparable between the four drainage types [Table 5].

Length of hospital stay was nearly equivocal. Two patients, both with nephrostomy drainage, had hospital readmissions. However, due to the disproportionate number of subjects between the groups the hospital readmission rate still remained statistically insignificant. There were no postoperative UTIs seen in the totally tubeless group. Fever was seen more in patients with nephrostomy drainage (nephrostomy tube + stent and nephrostomy tube) [Table 5]. One patient in the totally

**Table 3: Patient demographics, comorbidities, stone and procedure characteristics listed for each of the four PCNL drainage techniques**

Demographics	Nephrostomy tube + stent (n=54)	Nephrostomy tube (n=73)	Tubeless (n=26)	Totally tubeless (n=12)
Age	52.94±16.02 (23–85)	53.05±16.14 (22–85)	48.88±17.12 (10–86)	49.83±18.93 (26–85)
BMI	31.26±8.42 (15.06–52.03)	31.97±8.96 (15.06–52.03)	32.41±11.84 (15.50–74.69)	31.65±8.12 (21.30–47.11)
Prior lithotripsy (%)	18 (33.33)	27 (36.99)	3 (11.54)	0
Prior endoscopy (%)	10 (18.52)	14 (19.18)	4 (15.38)	2 (16.67)
Comorbidities (%)				
HTN	29 (53.70)	37 (50.68)	10 (38.46)	7 (58.33)
HLD	11 (20.37)	16 (21.92)	6 (23.08)	6 (50.00)
DM	12 (22.22)	17 (23.29)	4 (15.38)	4 (33.33)
CAD	3 (5.56)	4 (5.48)	2 (7.69)	3 (25)
CHF	0	0	0	0
Tobacco	22 (40.74)	27 (36.99)	2 (7.69)	6 (50)
Hypercalcemia	0	0	0	0
Recurrent UTI	6 (11.11)	9 (12.33)	1 (3.85)	3 (25)
CKD	4 (7.41)	4 (5.48)	0	1 (8.33)
COPD	4 (7.41)	5 (6.85)	0	0
Hypothyroid	5 (9.26)	8 (10.96)	3 (11.54)	2 (16.67)
Prior PCNL	6 (11.11)	9 (12.33)	0	1 (8.33)
Stone characteristics				
Largest stone size (mm)	13.11±3.23 (7–20)	13.29±3.24 (7–20)	11.42±2.50 (7–16)	11.50±2.88 (8–19)
Total stone burden (mm)	27.24±22.86 (9–121)	26.71±20.71 (9–121)	19.85±10.45 (10–45)	15.33±5.48 (8–24)

HTN: Hypertension, HLD: Hyperlipidemia, DM: Diabetes mellitus, CAD: Coronary artery disease, CHF: Congestive heart failure, UTI: Urinary tract infection, CKD: Chronic kidney disease, COPD: Chronic obstructive pulmonary disease, PCNL: Percutaneous nephrolithotomy, BMI: Body mass index

**Table 4: Stone free rates**

Stone free status	Total patients* (n=165) (%)
Complete stone free	133 (81)
Clinically stone free	138 (84)
CT postoperative image	95 (58)
KUB postoperative image	70 (42)

CT: Computed tomography, KUB: Kidney ureter bladder

tubeless group had hematoma development, however this did not require intervention and was managed with observation and pain control.

## DISCUSSION

Tubeless and totally tubeless PCNL demonstrates equivalent outcomes in the properly selected patient group when compared to PCNL performed with the presence of a nephrostomy tube (with/without stent).

Creatinine was unaffected by nephrostomy tube or stent suggesting consistent renal function despite drainage technique. Stone free status for each patient was indicative only of whether stones were radiographically visualized postoperatively, there was no gradient for how much of the stone (s) were removed during the procedure, which actually lowered our total SFR. Our study had comparable stone clearance rate as the Clinical Research Office of the Endourological Society study, which showed a 30-day stone-free rate of 75.7%.<sup>[16]</sup>

Length of hospital stay did not show a statistical difference in this study, unlike other studies.<sup>[12,15,17]</sup> This may be the result of an aggressive discharge pattern seen by the operative surgeon regardless of tube placement. Nephrostomy tubes were typically

not clamped and discontinued at bedside early morning postoperative day I, without further imaging performed prior. Ureteral stents remained indwelling at discharge until typically ten to fourteen days after procedure at the patients' first postoperative follow-up visit.

Most importantly, there was no statistical difference among the complication profiles when comparing the four PCNL procedures. This indicates tubeless and totally-tubeless PCNL can be performed safely and effectively in properly selected patients meeting our selection criteria. Our movement toward reducing placement of nephrostomy tubes and stents is to improve the patient's postoperative pain and discomfort as demonstrated by other studies.<sup>[7,13]</sup> Thus, by performing PCNL safely with the tubeless and totally-tubeless techniques, we can achieve significantly improved cost-effectiveness, patient pain profiles, and seek to improve length of hospitalization.<sup>[7,17,18]</sup>

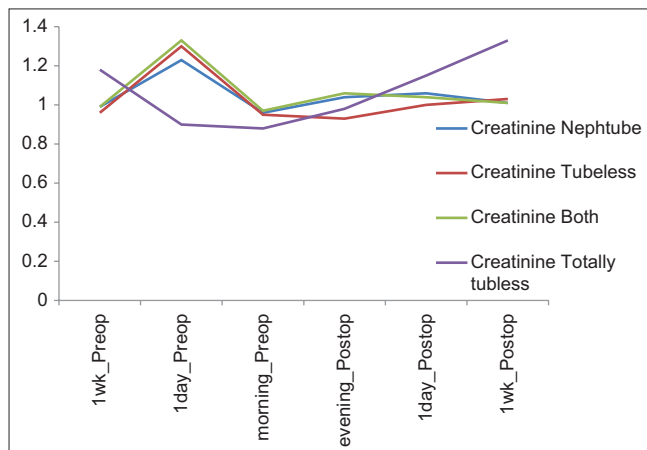
One of the most common complaints after urologic procedure is urine leakage and pain/discomfort associated with drainage tubes. Minimizing drainage tubes inserted at the conclusion of these procedures can decrease pain profile associated with these procedures.<sup>[13]</sup> Ultimately, there is potential to reduce patient hospital stay due to decreased analgesic requirements. Furthermore, this may springboard the potential for performing percutaneous renal surgery to the outpatient setting. This would follow the trends seen in the medical community and could potentially translate into healthcare savings.

Limitations of the study include the known inherent flaws of a retrospective study. When evaluating the four

**Table 5: Complication rates and clinical course of treatment groups**

Complications	Nephrostomy tube and stent (n=54) (%)	Nephrostomy tube (n=73) (%)	Tubeless (stent alone) (n=26) (%)	Totally tubeless (n=12) (%)
Percentage of patients with any complication	9 (16.67)	10 (13.70)	2 (7.69)	2 (16.67)
Pneumothorax	0	0	0	0
Blood transfusion	0	0	0	1 (8.33)
Urinary tract infection	2 (3.70)	3 (4.11)	2 (7.69)	0
Pneumonia	1 (1.85)	1 (1.37)	0	1 (8.33)
Clinically relevant pleural effusion	1 (1.85)	1 (1.37)	0	0
Hematoma	0	0	0	1 (8.33)
Fever	6 (11.11)	6 (8.22)	0	1 (8.33)
Urinary retention	1 (1.85)	1 (1.37)	0	0
Hospital course				
Length of stay (days)	1.53±0.76 (1-4)	1.53±0.76 (1-4)	1.54±0.77 (1-4)	1.50±1.00 (1-4)
Readmission rate	1 (1.85)	1 (1.37)	0	0
ER visit for pain	1 (1.85)	2 (2.74)	2 (7.69)	1 (8.33)

ER: Emergency room

**Graph 1:** Creatinine measured in the various treatment groups

drainage techniques individually, the power of the study is suboptimal primarily due to the sample size of totally tubeless patients ( $n = 12$ ). However, when evaluating the patients with ( $n = 127$ ) and without ( $n = 38$ ) nephrostomy tube drainage regardless of stenting, the power is strengthened without significantly altering the overall findings. There is inherent selection bias in the patient population groups due to the retrospective study design; the tubeless and totally tubeless PCNL cohort is likely a less complicated patient population.

## CONCLUSION

Tubeless and totally tubeless PCNL demonstrates equivalent outcomes in the properly selected patient group when compared to PCNL performed with the presence of a nephrostomy tube (with/without stent). Patients with history of previous PCNL procedure on the same kidney showed a disproportionately higher rate of nephrostomy placement. This may indicate that a surgical preference exists (selection bias) for placement of nephrostomy drainage based upon the patient's individual history, demonstrating a more cautious approach. As well, these patients may have undergone a more complex

stone treatment, as suggested by the exclusion criteria. The findings of this study are consistent with other post-PCNL drainage studies. Tubeless and totally tubeless PCNL can be performed in a safe and effective manner. Although this does not provide new knowledge to the medical literature, additional compounding data is clearly needed to swing the pendulum of the care, so that nephrostomy placement becomes the exception and not the standard in PCNL.

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**How to cite this article:** Abbott JE, Deem SG, Mosley N, Tan G, Kumar N, Davalos JG. Are we fearful of tubeless percutaneous nephrolithotomy? Assessing the need for tube drainage following percutaneous nephrolithotomy. *Urol Ann* 2016;8:70-5.

**Source of Support:** Nil, **Conflict of Interest:** None.