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Determinants of Nephrostomy Tube Dislodgment After Percutaneous Nephrolithotomy

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Abstract

Background and Purpose: Percutaneous nephrolithotomy (PCNL) traditionally necessitates the placement of a nephrostomy tube at the conclusion of the surgical procedure. Although tubeless PCNL has become more popular, patients with complex problems still need traditional nephrostomy tube drainage. The goal of this study was to investigate whether patient body mass index (BMI) impacted inadvertent nephrostomy tube dislodgment. Furthermore, we hoped to determine whether nephrostomy tube type impacted tube dislodgment rates.

Methods: A retrospective review between 2005 and 2012 of 475 consecutive PCNL cases was undertaken. Patients were categorized based on the type of nephrostomy tube placed. BMI was examined as a continuous variable. The primary outcome of nephrostomy tube dislodgment was determined based on imaging obtained at the time of PCNL and postoperative hospitalization. Logistic regression analysis was then used to adjust for nephrostomy tube type and BMI.

Results: Overall, 24 (5.5%) total patients experienced nephrostomy tube dislodgment postoperatively. The mean BMI for patients experiencing nephrostomy tube dislodgment was 39.7 vs 30.9 for those without tube dislodgment ($P < 0.0001$; 95% confidence interval [CI] 4.6 to 12.9). Using logistic regression and adjusting for the use tube type, BMI was an independent predictor of tube dislodgment ($P < 0.001$). For each unit of increase in BMI, the likelihood of tube dislodgment increased by 6% (1.06). After adjusting for BMI, however, nephrostomy tube type was not found to be an independent predictor of nephrostomy tube dislodgment.

Conclusions: Nephrostomy tube type did not influence nephrostomy tube dislodgment rates. As a patient's BMI increased, the likelihood of tube dislodgment increased in a directly proportionate fashion. This is possibly because of the nephrostomy tube being fixed directly to the mobile skin associated with their fat pannus. Although the nephrostomy tube type itself did not affect tube dislodgment rates, a redesigned nephrostomy tube or fixation device should take into account the above findings related to obese patients to reduce the likelihood of nephrostomy tube dislodgment.

Introduction

PERCUTANEOUS RENAL STONE REMOVAL was first described as early as 1941 by Rupel and Brown,¹ but it was not until the 1970s that Fernström and Johansson² first described removal of renal stones via a nephrostomy tube tract.³ Since then, percutaneous nephrolithotomy (PCNL) has continued to evolve. Traditionally, PCNL has involved the placement of a nephrostomy tube at the conclusion of the surgical procedure.

The nephrostomy tube serves many purposes including acting as a port for egress of stone debris, blood clots, and urine, thereby limiting obstructive uropathy and its associated urinary extravasation and possible postoperative urosepsis. It also helps to tamponade bleeding from the percutaneous tract and from the kidney, and supplies access for

postoperative contrast imaging studies such as nephrostography to help assess anatomy and determine stone-free status.⁴ Furthermore, nephrostomy tubes preserve and maintain renal access if a repeat procedure is needed to evacuate residual stone debris.⁵ The majority of urologists continue to place nephrostomy tubes after PCNL, especially in complicated cases where the risk of hemorrhage, urinary extravasation, urosepsis, and the need for a repeat procedure is high.^{4,6}

Accidental nephrostomy tube dislodgment can be a significant complication after PCNL leading to pain or fever from obstructive uropathy because of an obstructing stone or renal pelvic/ureteral edema, urinary extravasation, need for reoperation, renal hemorrhage, or urinary extravasation. A large variety of nephrostomy tubes are currently available including pigtail “Cope” catheters with a pull string-tethered

locking mechanism (with a variety of loop diameters); balloon retention catheters (including Foley and Councill catheters); chest tubes fashioned for renal drainage (typically pediatric varieties); and Malecot reentry tubes (with or without a filiform leader).⁷

There are limited data as to the factors that determine nephrostomy tube dislodgment after PCNL. Patient factors such as body mass index (BMI), the distance from the skin to the collecting system, and degree of hydronephrosis may influence the likelihood of tube dislodgment. Most, if not all, nephrostomy tubes after PCNL are secured to the skin at the puncture site in an effort to reduce tube dislodgment. In regard to BMI, obese patients with a large flank pannus make tube stability difficult; as the pannus moves, so does the fixed nephrostomy tube, and this is a major barrier to optimize/stabilize nephrostomy tube position.

In addition to these patient factors, the nephrostomy tube itself may influence the likelihood of dislodgment. To date, no widely accepted optimal nephrostomy tube exists, and it is unclear as to how the type of nephrostomy tube placed influences, if at all, tube dislodgment.

The ideal nephrostomy tube should be durable and able to maintain a stable position within the renal collecting system, resist kinking in and outside the body, allow for urine, blood/clots, and stone debris to exit the body, and minimize patient discomfort. The goal of this study was to elucidate how patient BMI impacted inadvertent tube dislodgment. In addition, we hoped to determine whether nephrostomy tube type had a significant impact on nephrostomy tube dislodgment rates.

Methods

A retrospective review of a prospectively maintained database between 2005 and 2012 of 475 consecutive PCNL cases performed by a single surgeon was undertaken. Patients were categorized based on the type of nephrostomy tube placed. Nephrostomy tube type included modified Foley catheters with their tips removed just distal to the retention balloon, Malecot reentry tubes with filiform tips, and Cope loop-like pigtail catheters. Initial access was performed by the urologists and was typically performed with fluoroscopic guidance. With access obtained, the nephrostomy tract was dilated to 30F with a balloon dilator; occasionally, sequential Amplatz dilation was performed instead.

Nephrostomy tubes were placed at the end of the procedure, and the tube type was based on the primary surgeon's preference. The modified Foley catheter with its tip cut off was the typical tube chosen for post PCNL drainage. Malecot reentry tubes with filiform tips were placed in patients in whom there was a possibility of poor drainage across the ureteropelvic junction; the filiform tip would bridge this region. Cope-like tubes were most often placed in patients who needed more long-term nephrostomy tube drainage, because the smaller tube diameter was thought to be more comfortable for the patient.

Proper nephrostomy tube placement was confirmed with intraoperative antegrade nephrostography confirming intrarenal placement with little to no angulation of the tube. After confirming appropriate intrarenal placement, the nephrostomy tube was then sewn in place and a dressing was applied. All guidewires were then removed, and the patient

was rolled to a prone position by the surgical and lifting teams onto the transport gurney/bed.

The primary outcome of nephrostomy tube dislodgment was determined by comparing the last intraoperative fluoroscopic image while the patient was in the prone position in the operating theater to same day recovery room imaging and to the nephrostomy tube location at the time of postoperative antegrade nephrostography. Antegrade nephrostography used for comparison was performed routinely 1 to 2 days postoperatively. Nephrostomy tube dislodgment was defined as a nephrostomy tube tip positioned outside the renal collecting system. In addition to nephrostomy tube displacement, BMI, estimated blood loss (EBL), and the site of renal puncture—upper, middle, lower, or multiple—were also examined.

Results

Complete information with regard to BMI was available for 433/475 patients reviewed; 212 were male and 221 female. The mean age was 56 years and the mean BMI was 31.4. A modified Foley catheter was placed in 332 patients, a Malecot tube was placed in 72, and a Cope loop pigtail nephrostomy tube in 29 patients. Overall, 24 (5.5%) total patients experienced nephrostomy tube dislodgment postoperatively. The mean BMI for patients experiencing nephrostomy tube dislodgment was 39.7 *vs* 30.9 for those without tube dislodgment ($P < 0.0001$; 95% confidence interval [CI] 4.6 to 12.9); Table 1. Overall, Malecot tubes dislodged in 12.5% of patients and all other tube types dislodged in 4.5% of patients. The average BMI of patients with Malecot tubes was 35.6 compared with 30.7 for all other tubes ($P = 0.0002$; 95% CI of 2.3765 to 7.4434). More women than men experienced nephrostomy tube dislodgment, 17 *vs* 7 ($P = 0.062$).

Using logistic regression and adjusting for the use of the Malecot tubes, BMI is an independent predictor of tube dislodgement (odds ratio [OR] 1.06, 95% CI 1.03–1.10, $P < 0.001$). For each unit of increase in BMI, the likelihood of tube dislodgment increased by 6% (1.06). After adjusting for BMI, however, the use of the Malecot nephrostomy tubes was not found to be an independent predictor of nephrostomy tube dislodgment (OR 2.37, $P = 0.07$, 95% CI 0.944–5.933); Table 2. Point of entry into the renal collecting system was also examined as a potential risk factor for tube dislodgement.

Data on caliceal entry point was present in 407 (90.4%) patients. Seventy-three percent of patients had lower pole

TABLE 1. SERIES DATA

	n	Tube dislodgement	Tube intact	P value
Patients	433	24	409	
Mean age	56	59	56	0.332
Male	212	7	205	
Female	211	17	194	
Mean BMI	31.4	39.7	30.9	<0.0001
Malecot tube	72	9	63	
Modified Foley	322	15	307	
Cope-like tube	29	0	29	

BMI = body mass index.

TABLE 2. MULTIVARIATE ANALYSIS

<i>Dislodgment</i>	<i>Odds ratio</i>	<i>SE</i>	<i>z</i>	<i>P> z </i>	<i>[95% CI]</i>
BMI	1.064	.018	3.62	>0.001	1.029–1.101
Malecot	2.367	1.109	1.84	0.066	0.945–5.934

SE = standard error; CI = confidence interval.

only punctures, 20% had an upper pole puncture, 5% of patients had multiple pole punctures, 1% had midpolar punctures, and a single patient had an unspecified preexisting tract that was used for access. Of the 24 total tubes dislodged, 18 were lower pole sites, 5 were upper pole, and one was through the unspecified preexisting tract. Statistical analysis showed no statistically significant association between the calix of entry and tube dislodgment.

In addition to caliceal entry, data on EBL were present in 315 of our total 475 patients. The mean EBL of patients with tube dislodgment vs no tube dislodgment was 92 vs 107 milliliters, respectively. This was not found to be of statistical significance. Again, multiple access sites with a single nephrostomy tube for drainage were used in 22 patients, but there were no tube dislodgments in this patient group. Multiple nephrostomy tubes were used in 14 patients, and in only one of these did tube dislodgment occur.

Discussion

Data regarding nephrostomy tube dislodgment rates after urologist-directed PCNL are lacking. This series provides more insight into this because it only represents patients undergoing urologist-directed PCNL access primarily via a lower pole calix. As was the case in this series, the majority of patients continue to have nephrostomy tubes placed at the conclusion of a PCNL despite the increased popularity for tubeless procedures. In fact, most PCNL procedures are performed for patients with complex stone anatomy and/or increased stone burden. Many "tubeless" procedures have an antegrade Double-J ureteral stent placed rather than a nephrostomy tube.

In our hands, there are minimal patient complaints regarding pain and discomfort related to the nephrostomy tubes. We and others have, however, noted patient complaints regarding Double-J ureteral stent irrigative voiding symptoms and the need for an additional procedure, the cystoscopic postoperative stent removal. Double-J ureteral stents do not optimize kidney drainage, and this is critical in patients with potential infectious complications. If one is going to place a nephrostomy tube, one prefers to have it remain in the correct position postoperatively. Therefore, the knowledge of various nephrostomy tube options when combined with patient characteristics to yield the most stable drainage method is critical.

To our knowledge, this study represents the largest series to date regarding varied nephrostomy tube types and their respective dislodgment rates. Dislodgment rates ranging from 1% to >30% are found in the literature.^{8,9} Saad and colleagues⁹ reviewed case histories for 329 adult IR directed PCNL tubes and found a total short-term dislodgment rate of 5%. Overall, 37.8% of the nephrostomy tubes placed were performed for calculi and 100% were pull-string re-

ention tubes, Cope-loops. Our series had a similar dislodgment rate, but, interestingly, no Cope-loop tubes were dislodged.

Although Malecot reentry nephrostomy tubes have the greatest rigidity and length, when including its filiform tip, they represented the tubes most likely to become dislodged in this series. This higher rate of dislodgment of Malecot tubes, however, was not statistically significant when corrected for confounding variables such as BMI. Therefore, no nephrostomy tube was statistically more likely to become dislodged than another when corrected for patient BMI. This could be secondary to securing the nephrostomy tubes with skin sutures. This may actually lead to increased tube dislodgment with movement of the overlying pannus in obese patients. This is simply a conjecture, because, unfortunately, subjective data regarding the presence of a patient's pannus were not available on retrospective review. Furthermore, Malecot nephrostomy tubes lack a Foley catheter retention balloon mechanism or Cope loop-like pull-string retention system. These static mechanisms may offer greater resistance to dislodgment compared with the passive phalanges of the Malecot tubes.

Obesity rates continue to rise within the United States, with more than one-third of adults (35.7%) being obese (BMI ≥ 30). This is not only a U.S. epidemic, but represents a global health issue. Obesity affects nearly all medical disciplines.¹⁰ Obese patients are more likely to have heart disease, diabetes mellitus, decreased mobility, and nephrolithiasis.^{11,12} Therefore, the frequency of urologic surgical intervention in obese patients is likely to continue to rise. It is of no surprise then that the mean BMI, 31.4, within this entire series falls within the obesity category and the mean BMI, 39.7, of patients with tube dislodgment is essentially morbid obesity.¹³

A statistically significant difference was identified between the BMIs of patient with or without nephrostomy tube dislodgment. As mentioned previously, with each unit increase in BMI, nephrostomy tube dislodgment increased by 6%. The laxity of the overlying skin and subcutaneous structures likely allows for increased mobility of the nephrostomy tube at its point of fixation. In our series, all nephrostomy tubes were affixed to the patient's skin at the point of entry. The mobile fat pannus that the nephrostomy tube was affixed to might have placed increased stress on the retention mechanism of the nephrostomy tube.

Although not found to be of statistical significance, the majority of renal access in this series was obtained via a lower pole puncture site, and the fat pannus tends to be larger and more mobile in this region in comparison with the upper pole region of the kidney. Post-PCNL nephrostomy tube dislodgment likely occurs during times of patient repositioning, whether on the hospital floor under the direction of support staff, movement initiated by the patient, or during maneuvering from a prone to supine position in the operating room.

Malecot reentry tubes potentially represent the tube type with the weakest mechanism for retention and therefore the most likely prone to dislodgment despite being the most rigid. This begs the question, what represents the ideal or more stable nephrostomy tube? To address this issue, attempts have been made at improving current nephrostomy tubes. Ostendorf and associates¹⁴ devised a strategy for reinforcing small caliber nephrostomy tubes used in pediatric PCNLs. The overall goal of this modification was to increase the

rigidity of the nephrostomy tube and, therefore, has little application in reduction of tube dislodgment or most adult PCNLs. Zhou and coworkers¹⁵ did devise a novel modification to Cope-like tubes to decrease dislodgment rates. They used a rubber drainage tube, cut it along its longitudinal axis, and then encased the nephrostomy tube with it. They then sutured the cut edges together with the skin to reinforce the nephrostomy tube.

Although they did find a statistically significant decrease in nephrostomy tube dislodgment rates, we think a more optimal tube design would more aptly accommodate the mobility of the skin fixation. Therefore, a nephrostomy tube with a pigtail or balloon retention system combined with an accordion-like nephrostomy tube traversing the skin to kidney distance would allow for greater flexibility and presumably decreased tube dislodgment. A drawback of a design such as this is that it could also allow for kinking or bending of the nephrostomy tube within the perinephric space causing obstruction of the nephrostomy tube itself. Further optimizing nephrostomy tube designs is a complex issue. The best solution might be to not secure the tube at all to the fat pannus in obese patients.

We recognize limitations of our series. Its retrospective design is not as preferable to a randomized control trial, but this series represents one of the largest to date investigating nephrostomy tube dislodgment. When correcting for BMI, there was no statistically significant increase in the likelihood for Malecot tubes to become dislodged. Malecot tubes were placed in the most obese patients, which represented a confounding factor for tube dislodgment. This was corrected for, however, with statistical analysis, and the knowledge that Malecot tubes do not prevent dislodgment in obese patients is useful knowledge going forward.

Conclusions

Despite Malecot reentry tubes having greater rigidity and a long filiform tip, they did not prevent dislodgment. As a patient's BMI increased, the likelihood of tube dislodgment increased in a directly proportionate fashion, possibly because of the tube being fixed to the mobile skin associated with their fat pannus. Factors such as nephrostomy tube type, EBL, or site of PCNL access did not affect rates of dislodgment. Designing the optimal nephrostomy tube should take these issues into account to decrease the likelihood of tube dislodgment.

Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

BMI $\frac{1}{4}$ body mass index
 CI $\frac{1}{4}$ confidence interval
 EBL $\frac{1}{4}$ estimated blood loss
 IR $\frac{1}{4}$ interventional radiology
 OR $\frac{1}{4}$ odds ratio
 PCNL $\frac{1}{4}$ percutaneous nephrolithotomy