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Percutaneous Renal Access by Urologist or Radiologist: A Review of the Literature

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the preferred treatment for renal calculi greater than 2cm in diameter. In both the United States and United Kingdom, interventional radiologists often perform percutaneous access rather than urologists obtaining their own access.

Objectives: We present a local cohort of urologist versus radiologist obtained percutaneous access and a relevant literature review. In addition, access techniques and the role of training urologists to obtain percutaneous access are reviewed.

Patients and Methods: The records of 233 patients undergoing PCNL at the University of Pittsburgh Medical Center (UPMC) between 2000 and 2008 were retrospectively reviewed. Patients were stratified according to percutaneous access by urologists (group 1) or a group of interventional radiologists (group 2) in 195 and 38 patients, respectively. Radiologist-acquired access was performed for collecting system decompression in 33.3% of patients in group 2. A predicted access difficulty score was calculated using demographic, stone, and operative variables. Percutaneous access complications and stone-free rates were compared between groups. A Medline search of pertinent articles was conducted. Additional sources were identified from the reference sections of relevant manuscripts.

Results: Rates of stone clearance are superior with urologist-obtained renal access as compared to radiologist-obtained access when there is no preoperative communication between groups. Complication rates are similar between groups. Among urologists, the learning curve for PCNL is 60 cases for competence and 100-115 cases for excellence. Several models for virtual training in percutaneous renal access are available. The use of retrograde endoscopy can reduce the number of tracts required for access, thereby reducing perioperative blood loss. Ultrasound has been used as an adjunct imaging modality for PCNL and reduces the risk of radiation to patients and staff.

Conclusions: Urologists can safely obtain percutaneous renal access. Further training during and after residency is necessary to increase the number of urologists capable of obtaining access for PCNL. A number of virtual models are available to facilitate training. Endoscopic-assisted percutaneous renal access may decrease the steep learning curve associated with obtaining percutaneous access. Efforts should be made to decrease the use of ionizing radiation during PCNL.

▸ *Implication for health policy/practice/research/medical education:*

Percutaneous nephrolithotomy is the preferred treatment for renal calculi greater than two centimeters. Precise percutaneous access is required for optimal treatment outcomes. This is best performed either by the urologist who will be treating the renal calculus or by an interventional radiologist in close communication with the urologist. In addition, percutaneous renal access and urologist training in these techniques are reviewed.

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1. Background

Percutaneous nephrolithotomy (PCNL) is an accepted and established technique for the management of large and complex renal calculi (1). The 2005 American Urological Association Guidelines recommend PCNL as the first line treatment for renal calculi greater than 2.0 cm in diameter (2). In the United States and United Kingdom, percutaneous renal access is often obtained by interventional radiologists (3, 4). A recent review of stone treatment patterns revealed that only 11% of practicing urologists obtain their own access prior to PCNL (5). Training in the surgical treatment of large volume nephrolithiasis presumably benefits urologists who obtain their own percutaneous access by their ability to create multiple tracts for optimal stone treatment (6).

2. Objectives

The current review presents a local experience with urologist and radiologist who obtained percutaneous access for the treatment of large volume renal calculi and a rigorous review of the literature. Techniques for percutaneous renal access and urologist training paradigms are reviewed.

3. Patients and Methods

A retrospective review of 233 patients undergoing PCNL at a single institution from July 2000 to January 2008 was performed. Patients were stratified according to percutaneous access by urologists (n=195, group 1) or a group of interventional radiologists (n=38, group 2). Given the retrospective study design, the groups were not equal in size. Whether performed for urinary decompression or stone treatment, radiologist-acquired access was obtained without urologic consultation. All radiologist-obtained access in this cohort was performed independently from definitive stone treatment and occasionally for separate reasons (i.e. collecting system decompression). In group 1, cystoscopy and ureteral catheter placement were performed at the beginning of the procedure. Air and/or contrast medium was injected to opacify the collecting system, and access was obtained under multidirectional C-arm guidance. For patients within group 2, access was obtained under ultrasonographic and/or fluoroscopic guidance after percutaneous antegrade contrast injection. Preoperative, operative, and postoperative details were recorded and analyzed for each patient with regard to blood loss, outcomes, and complications. Percutaneous access techniques for the UPMC cohort have been previously described.(7) A Medline literature review was conducted using the key words "percutaneous nephrolithotomy," and "percutaneous nephrostomy" for articles published from 1990 to 2011. Search results were reviewed and included based on relevancy. Additional sources were accessed from the reference sections of relevant articles. A total of 47 relevant articles were reviewed.

4. Results

4.1. Urologist versus Radiologist Obtained Percutaneous Access

In the local cohort indications for radiologist access included obstruction and infection (33.3%), position limiting contracture (15.2%), previous genitourinary reconstruction (10.5%), solitary (7.9%) and horseshoe (2.6%) kidneys, and limited retrograde access (8.3%); 22.2% were referred from an outside hospital with nephrostomy tubes in place (7). There were no significant differences in the use of multiple access tracts, mean stone diameter, percentage of supracostal access, mean access difficulty parameters, percentage of staghorn calculi, or number of obese patients between groups. Complications between groups were comparable. On univariate analysis, the urologist access group had a significantly higher stone-free rate when compared to the radiologist access group (99% *vs.* 92.1%, $P = 0.033$). In addition, radiologist access was unusable for stone treatment in 36.8% of patients, which necessitated additional access tract creation prior to surgery. In settings where percutaneous access is routinely performed as a separate procedure, the high rate of unusable radiologist obtained access underscores the importance of collaboration between urologists and radiologists to minimize the morbidity of repeated access attempts. Watterson *et al.* (8) retrospectively reviewed complications associated with percutaneous nephrostomy placement for PCNL in 49 and 54 patients in whom the procedure was performed by a single urologist or a group of interventional radiologists, respectively. Access difficulty scores, supracostal tract formation, patient age, and ASA scores were comparable between groups. Despite having a significantly larger stone burden, the urology access group had greater stone-free rates (86% *vs.* 61%, $P = 0.01$). Moreover, access related complications were significantly greater in the radiology access group (15 *vs.* 5, $P = 0.02$). The authors concluded that urologist-obtained percutaneous access is safe and results in improved stone-free rates.

El-Assmy *et al.* (9) retrospectively compared 509 patients who underwent percutaneous access by urologists with 612 patients in whom access was obtained by interventional radiologists. The only preoperative difference between groups was a higher number of patients with multiple stones in the urology access group. Access difficulty parameters were also higher in the urology access group, with greater use of multiple tracts, supracostal access, and a higher number of solitary kidneys. Complications were similar between groups with the notable exception of a higher incidence of bleeding in the urology access group. On multivariate analysis, significant risk factors for severe bleeding were upper tract puncture, solitary kidney, staghorn calculus, and multiple punctures. They attributed the higher incidence of bleeding in the urology access group to greater use of multiple tracts. Interestingly, the authors found no difference in stone-free rates between urologist and radiologist obtained access (83.4% *vs.* 86.1%, respectively). An important difference of this cohort is that radiologist access was performed preoperatively as part of a staged procedure, which implies there was communication between the urologists performing PCNL and the radiologists obtaining access. Perhaps under circumstances of close collaboration, stone-free rates are more likely to be similar regardless of who obtains access.

5. Discussion

5.1. Urologist Training In Percutaneous Access

Adequate training during residency or fellowship is paramount to increasing the number of urologists obtaining their own access for PCNL (5). Lee and colleagues examined the effect of residency training in percutaneous access on clinical practice (10). Not surprisingly, urologists trained in percutaneous access during residency were significantly more likely to perform percutaneous procedures in clinical practice compared to untrained urologists (92% and 32% respectively). Moreover, urologists who were comfortable gaining their own percutaneous access performed significantly more percutaneous access procedures during residency (24.4 ± 5.6) compared to those who were uncomfortable (10.6± 3.1). Thus, increasing residency training in percutaneous access should increase the number of urologists obtaining their own percutaneous access.

One difficulty in teaching percutaneous access is the steep and measurable learning curve associated with PCNL (11-13). Using factors such as stone clearance, complication rate, operative time, and fluoroscopic screening time, it is estimated that 60 and 100-115 cases are required to obtain surgical competence and excellence, respectively. Further estimates indicate that approximately 500 new stone cases per year are required for one resident to obtain proficiency in percutaneous access (14), volumes which are only likely to be met at major stone centers. Thus, there is an acute need for virtual training modules to educate urology residents in techniques of percutaneous renal access. Several groups have described an ex-vivo model for percutaneous procedures using porcine kidneys preimplanted with makeshift calculi and surrounded by chicken carcasses (15-17). Using these methods, the porcine ureter can be cannulated and air pyelogram or contrast media can be infused in a retrograde fashion to facilitate percutaneous access, stone manipulation/removal, and endopyelotomy. Live porcine models and virtual reality (VR) simulators such as the PERC Mentor (Symbionix™, Cleveland, OH) have been described and validated (18, 19). In a recent comparison between VR and a live porcine model (20), 24 "experts" at obtaining percutaneous access rated the porcine model superior to the VR model in "overall realism," "movement of the kidney," and "tactile feedback of the perinephric space." The VR model was superior in "orientation to the flank," "aspiration," "repetitive performance," and "organizational feasibility." A variety of simulation options are available to familiarize residents with the technical aspects of percutaneous renal access.

5.2. Endoscopy-assisted Percutaneous Access: An Answer to the Steep Learning Curve?

Endoscopic assistance during percutaneous renal access has the potential to decrease complications associated with the procedure and thereby facilitate training. Endoscopy-assisted percutaneous renal access was first reported in a salvage context by Grasso and colleagues in seven patients (21). Later, Kidd and Conlin presented a case series of endoscopy-assisted renal access in 3 patients whose associated conditions would have made traditional access difficult (22). Various modifications and technical aspects have been described with particular success in obese patients or those with large stone burden and renal ectopy (23, 24). Recently, Sountoulides *et al.* (25) compared outcomes between a group of 51 and 70 patients who underwent endoscopy-guided and standard fluoroscopy-guided percutaneous access, respectively. There were no differences between groups with regard to post-procedure embolization, narcotic use, change in glomerular filtration rate, or stone free rate. Blood loss and transfusion rates were significantly less in the endoscopic-assisted group. Blood loss is one of the most common complications of PCNL (26) and the use of multiple access tracts has been shown to increase risk of bleeding during PCNL (27, 28). Retrograde ureteroscopic lithotripsy with subsequent endoscopic-assisted percutaneous access has been used to minimize the number of access tracts required for treatment of large volume renal calculi, thereby reducing the risk of bleeding (29). Endoscopic-assisted percutaneous access is a natural translation of ureteroscopic skills to facilitate renal access during PCNL, and has been shown to decrease blood loss and minimize the number of tracts required during PCNL. Because most urologists are already familiar with ureteroscopy, it may be a useful tool to decrease the learning curve associated with percuntaneous renal access.

5.3. Percutaneous Access Techniques: Minimizing Radiation

5.3.1. Fluoroscopy vs. Ultrasound (US)

Percutaneous renal access for PCNL has traditionally been performed using fluoroscopic guidance, and the details of obtaining access have recently been reviewed in eloquent detail (30, 31). Briefly, there are two common techniques for obtaining fluoroscopically-guided access: the eye of the needle or "bulls-eye" method and triangulation. Both have proven successful in the management of large renal calculi, but there has been increasing concern regarding the effects of radiation exposure with the use of conventional fluoroscopy (32-35). Modifications to current fluoroscopic techniques have been advocated to minimize radiation exposure (36). Interest remains, however, in further minimizing radiation risk, and ultrasonography has emerged as an adjunct imaging modality to reduce radiation exposure. Osman *et al.* (37) published their experience with over 300 patients using US-guided percutaneous access followed by fluoroscopic-guided tract dilation and subsequent lithotripsy. They reported a stone free rate of 96.5%, and 3 significant complications including one death from urosepsis and concluded that US-guided renal access and performance of PCNL at experienced centers could potentially reduce complications associated with PCNL. Agarwal and colleagues (38) performed a prospective randomized trial comparing fluoroscopic guidance alone and US combined with fluoroscopic-guided renal access. The use of US shortened time to successful puncture and decreased duration of radiation exposure without compromising stone free rates. In a comparison of traditional prone fluoroscopic PCNL to US-guided PCNL in the flank position (39), US decreased the time required to obtain access. US-guidance reduces radiation exposure to patients and operating room staff and can be considered an acceptable alternative to fluoroscopic-guided PCNL. Other groups have also reported success with US-guided percutaneous access (40-42). One possible advantage US provides is Doppler technology, which can help visualize and avoid renal blood vessels during percutaneous puncture (43). A chief criticism against the use of ultrasound for percutaneous renal access may be the lack of familiarity with its use. Simulated training programs have been developed in an effort to provide education prior to undertaking supervised procedures on patients (44). More information is needed to determine the precise role of US in PCNL; however, the prospect of reducing or even eliminating ionizing radiation exposure is attractive. Training programs should incorporate the routine use of US for PCNL to increase familiarity with its use.

5.3.2. Blind Puncture

The need for blind percutaneous access is exceedingly rare and limited to situations in which traditional radiographic guidance is precluded or unavailable. Interest in blind percutaneous access centers around the decreased risk of radiation exposure and the cost-savings gained. Chien and colleagues (45) described the blind access technique in 40 patients who could not tolerate intravenous contrast administration and in whom retrograde access had failed. The lumbar notch is identified as an indentation where the 12th rib crosses the paraspinous muscles. Anatomic boundaries are the latissimus dorsi muscle and 12th rib superiorly, the sacrospinalis and quadratus lumborum muscles medially, and the transversus and external oblique muscles laterally. An 18-guage needle is inserted at the lumbar notch at 30° from the skin and pointed cephalad and advanced 3-4cm underneath the 12th rib. The inner needle obturator is removed while steady suction with a 10ml syringe is applied until collecting system access is confirmed by aspiration of urine. Contrast can then be used to opacify the collecting system and optimize access for the planned procedure. In their series, only one patient required ultrasound-guidance to obtain access. The average number of punctures was 2.5/case and there were no reported complications. Stone clearance outcomes were not reported.

In a prospective randomized study, Karami *et al.* (46) compared the use of blind puncture and tubeless nephrolithotomy to retrograde ureteroscopy and pneumatic lithotripsy in 70 patients with impacted ureteral calculi greater than 1 cm. The success rate for blind puncture was 100% (80% renal pelvis, 20% lower pole calyx), with a 100% stone free rate. In the transurethral ureterolithotripsy (TUL) group, calculi migrated into the renal collecting system in 34.2% of patients, and were incompletely fragmented in 14.2%. Mean operative times were similar between PCNL and TUL (38m vs. 34m, respectively). The authors concluded that blind access and PCNL in the setting of large impacted ureteral calculi is safe, effective, and delivers less radiation than TUL. Basiri *et al.* (47) compared blind puncture with fluoroscopic-guidance in PCNL. One hundred patients were randomly assigned to blind access (group 1) or traditional fluoroscopic-guided puncture (group 2). Mean time to access was significantly less in group 2 (5.5 ± 1.7 minutes, $P = 0.008$). Puncture of the targeted calyx occurred successfully in 50% and 90% of patients in groups 1 and 2, respectively ($P < 0.001$). Complete and successful stone removal was accomplished in 62% and 100% of the patients in groups 1 and 2, respectively ($P < 0.001$). There were no reported complications in either group. The authors concluded that fluoroscopic-guided access leads to superior treatment outcomes, though blind puncture is an alternative for skilled surgeons interested in reducing radiation exposure.

Percutaneous renal surgery has a defined role in the treatment of large volume renal calculi. Surveys of practicing urologists have indicated that many are not comfortable obtaining their own percutaneous renal access and often rely on interventional radiologists to perform access independently. Accumulating data support the safety and efficacy of urologist obtained percutaneous access. Increased effort should be made to properly train urologists in gaining percutaneous renal access. Several virtual reality models are available to facilitate training. Endoscopic-assisted percutaneous renal access may be a useful adjunct in overcoming the steep learning curve associated with PCNL access. Finally, techniques that minimize ionizing radiation to both the patient and operating room staff should be emphasized in future training protocols.

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Conflict of interest

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