Direct Endoscopic Visualization Combined with Ultrasound Guided Access during Percutaneous Nephrolithotomy: A Feasibility Study and Comparison to a Conventional Cohort

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Purpose: Percutaneous nephrolithotomy access may be technically challenging and result in significant radiation exposure. In an attempt to reduce percutaneous nephrolithotomy radiation exposure, a novel technique combining ultrasound and direct ureteroscopic visualization was developed and reviewed.

Materials and Methods: Ureteroscopy without fluoroscopy was used to determine the optimal calyx for access, which was punctured with a Chiba needle under percutaneous ultrasound guidance. Next a wire was passed into the collecting system and ureteroscopically pulled into the ureter using a basket. Tract dilation and sheath and nephrostomy tube placement were performed under direct ureteroscopic visualization. Twenty consecutive patients undergoing this novel technique were reviewed and compared to 20 matched patients treated with conventional percutaneous nephrolithotomy. Mann-Whitney U and Pearson chi-square tests were used for comparisons with $p < 0.05$ considered significant.

Results: Using this novel technique mean fluoroscopy access time was 3.5 seconds (range 0 to 27.9) and mean total fluoroscopic time was 8.8 seconds (range 0 to 47.1). Mean operative time was 232 minutes (range 87 to 533), estimated blood loss was 111 ml, the stone-free rate was 65% and the complication rate was 25%. Compared to 20 matched conventional percutaneous nephrolithotomy cases, there was no difference in operative time ($p=0.76$), estimated blood loss ($p=0.64$), stone-free rate ($p=0.50$) or complications ($p=1.00$). However, the novel technique resulted in a significant reduction in fluoroscopy access time (3.5 vs 915.5 seconds, $p < 0.001$) and total fluoroscopy time (8.8 vs 1,028.7 seconds, $p < 0.001$).

Conclusions: This study demonstrates the feasibility of combined ultrasound and ureteroscopic assisted access for percutaneous nephrolithotomy. A greater than 99% reduction in fluoroscopy time was achieved using this technique.

Key Words: nephrostomy, percutaneous; ultrasonography; ureteroscopy; radiation protection; fluoroscopy

Abbreviations and Acronyms

ASA® = American Society of Anesthesiologists®

BMI = body mass index

CT = computerized tomography

EBL = estimated blood loss

KUB = plain x-ray of the kidneys, ureters and bladder

PCNL = percutaneous nephrolithotomy

SFR = stone-free rate

US = ultrasound

Accepted for publication January 12, 2016.

No direct or indirect commercial incentive associated with publishing this article.

The corresponding author certifies that, when applicable, a statement(s) has been included in the manuscript documenting institutional review board, ethics committee or ethical review board study approval; principles of Helsinki Declaration were followed in lieu of formal ethics committee approval; institutional animal care and use committee approval; all human subjects provided written informed consent with guarantees of confidentiality; IRB approved protocol number; animal approved project number.

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Radiation exposure from medical imaging has increased by 600% from 1980 to 2006, currently accounting for more than 50% of the United States' effective radiation dose exposure.[1] It is estimated that noncontrast CT delivering 10 mSv radiation is responsible for fatal malignancy in 1

0022-5347/16/1961-0227/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2016.01.118
Vol. 196, 227-233, July 2016
Printed in U.S.A.

in 2,000 patients,[2] with an estimated 29,000 cancers arising from CT in 2007 alone.[3] Although the major contributor to radiation exposure is diagnostic CT, a significant percentage of medical imaging radiation is also attributed to fluoroscopy.[1]

PCNL is a challenging procedure that may require significant amounts of fluoroscopy. Many percutaneous access techniques have been described but the majority use fluoroscopy to guide needle placement[4–8] and risk radiation exposure to patient and operating room staff.[9] In response to substantial increases in radiation doses used for medical procedures,[10] the Food and Drug Administration has targeted fluoroscopy as one of the modalities that requires optimization to comply with the recommended ALARA (as low as reasonably achievable) principle.[11]

In an attempt to minimize radiation exposure and to improve calyceal access site accuracy, we describe a novel technique using combined ureteroscopic visualization with ultrasound guidance to achieve percutaneous renal access. After successfully implementing this technique in 20 consecutive patients treated with PCNL, we then compared the outcomes to those of a matched conventional cohort where fluoroscopy was used for all steps of PCNL.

MATERIALS AND METHODS

A retrospective review of all PCNL cases performed by a single surgeon using the novel US guided, ureteroscopic directed access was performed from March 2013 to March 2014. Demographic and perioperative information recorded included age, BMI, ASA score, laterality, access site and presence of hydronephrosis. Stone burden was assessed by preoperative CT or KUB, where for each stone the cross-sectional area was calculated by multiplying length by width. The cross-sectional area of all stones was then summed and reported as the total stone burden.

Twenty consecutive patients who had undergone the novel technique were compared to 20 patients who had undergone fluoroscopic guided access. To eliminate expected confounding factors the 2 cohorts were matched by stone burden, ASA score, access location and BMI. Exclusion criteria were patients with cystine stones, transplant kidneys and duplicated collecting systems. None of the novel technique cohort met the exclusion criteria and, thus, all patients were included in the study.

Primary outcomes included access fluoroscopic time and total fluoroscopic time. Secondary outcomes included operative time, EBL, SFR (residual stone size less than 4 mm on CT), hospital stay and complications. For patients who had renal access performed by interventional radiology in a prior procedure, total operative time and total fluoroscopy time were calculated by adding the time for access and the time for the stone treatment procedure. An independent samples Mann-Whitney U test and Pearson chi-square test were used for comparisons, with $p < 0.05$ considered statistically significant.

US Guided Ureteroscopic Assisted PCNL

Each patient was placed under general anesthesia and positioned in the prone and split leg position. Drawing from previous experience we performed ureteroscopy without fluoroscopy which has been previously published.[12] Under ureteroscopic visualization, real-time direct endoscopic mapping allowed the surgeon to select the ideal calyx for percutaneous access (fig. 1). Selection of this entry site also required the surgeon to be aware of rib location. Ultrasonography was used to identify the rib when not easily palpated.

Percutaneous access was obtained with a 20-21 gauge Chiba needle (Cook Medical, Bloomington, Indiana) under ultrasonographic guidance (GE LOGIQ e with a 4C probe, GE Healthcare) by an experienced interventional radiologist (JCS, EL) (fig. 2). The selected calyx is first identified on ultrasound when the ureteroscope is gently deflected back and forth to allow the motion to be detected (fig. 3).

Ultrasonography ensures no lung or abdominal viscera are at risk for injury. Proper calyceal access is confirmed ureteroscopically (fig. 4). If the needle is not centered in a calyx, minor adjustments can be made under ureteroscopic visualization. A 0.018-inch mandril wire from an Aprima™ access set is passed through the needle, basketed ureteroscopically and pulled into the proximal ureter (fig. 5). Next the Aprima sheath is used to place a 4Fr Glidecath® and a 0.038-inch angle-tipped glidewire (Terumo Medical Corporation, Somerset, New Jersey) into the bladder. The glidewire is then exchanged for an Amplatz extra-stiff guidewire (Cook Medical). A dual lumen catheter is used to place the Glidecath/glidewire combination, which is converted to a 0.038-inch standard Teflon™ coated safety guidewire (Cook Medical) using the 4Fr Glidecath. Balloon dilation and sheath placement are performed under direct ureteroscopic visualization, which

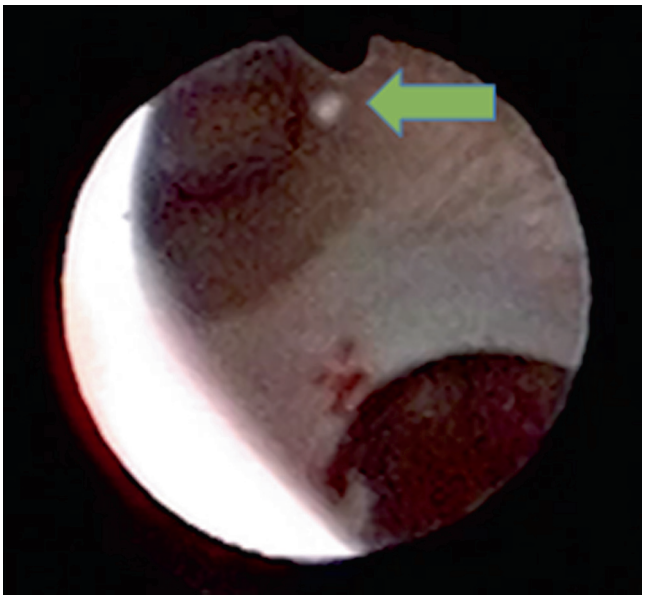

Figure 1. Direct endoscopic visualization of desired access location. Presence of air bubble (green arrow) can help identify location of posterior calyx.