Reduced Fluoroscopy Protocol for Percutaneous Nephrostolithotomy: Feasibility, Outcomes and Effects on Fluoroscopy Time

Brian Blair, Gene Huang, Don Arnold, Roger Li, Amy Schlaifer, Kirk Anderson, Steven Engebretsen, Caroline Wallner, Gaudencio Olgin and D. Duane Baldwin*,†

From the Loma Linda University Medical Center, Loma Linda, California

Abbreviations and Acronyms

BMI = body mass index
CT = computerized tomography
EBL = estimated blood loss
IR = interventional radiology
IVP = excretory urogram
kVp = peak kilovoltage
mAs = milliampere seconds
PCNL = percutaneous nephrostolithotomy

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* Correspondence: Department of Urology, Loma Linda University School of Medicine, 11234 Anderson Street, Room A560, Loma Linda, California 92354 (Telephone Number: 909-558-4196; Fax Number: 909-558-4806; e-mail: dbaldwin@llu.edu).

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Purpose: Radiation exposure from fluoroscopy during percutaneous nephrostolithotomy contributes to patient overall exposure, which may be significant. We compared fluoroscopy times and treatment outcomes before and after implementing a reduced fluoroscopy protocol during percutaneous nephrostolithotomy.

Materials and Methods: We retrospectively reviewed the charts of patients treated with percutaneous nephrostolithotomy at a single academic institution by a single surgeon. We compared 40 patients treated before implementation of a reduced fluoroscopy protocol to 40 post-protocol patients. The reduced protocol included visual and tactile cues, fixed lowered mAs and kVp, a laser guided C-arm and designated fluoroscopy technician, and single pulse per second fluoroscopy. Preoperative characteristics, fluoroscopy and operative time, complications and treatment success were examined using univariate and multivariate analysis.

Results: There was no significant difference in body mass index, stone size, success rate, operative time or complications between the groups. After protocol implementation fluoroscopy time decreased from 175.6 to 33.7 seconds ($p < 0.001$). A longer average hospital stay was seen in the pre-protocol group (3.9 vs 3.6 days, $p = 0.027$). Stays greater than 2 days were associated with a body mass index of greater than 30 kg/m^2 on multivariate analysis. No complication in either group was attributable to fluoroscopic technique.

Conclusions: Implementing a decreased fluoroscopy protocol during percutaneous nephrostolithotomy resulted in an 80.9% reduction in fluoroscopy time while maintaining success rates, operative times and complications similar to those of the conventional technique. Adopting this reduced fluoroscopy protocol safely decreased radiation exposure to patients, surgeons and operating room staff during percutaneous nephrostolithotomy.

Key Words: kidney; fluoroscopy; nephrostomy, percutaneous; radiation dosage; safety

Radiation administered to patients for medical imaging increased substantially in the last 3 decades. Subsequently, concern has increased about the effects of ionizing radiation and its potential to cause cancer.[1,2] Brenner and Hall estimated that 1.5% to 2.0% of cancers in the United States are attributable to CT radiation exposure.[3] For each 1,000 patients

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exposed to 10 mSv radiation cancer is expected to develop in 1 as a result of that exposure.[4]

Patients with urolithiasis represent a population at risk for repeat radiation exposure. In the year after an acute stone episode patients receive an average of 4 radiographic examinations with an estimated effective dose of 34 mSv from abdominopelvic CT, 2.5 mSv from excretory urogram and 1.8 mSv from plain x-ray of the kidneys, ureters and bladder.[5] In patients with a large volume of renal calculi fluoroscopy is routinely done during PCNL and it can be an additional source of significant radiation exposure.

Perioperative low dose CT is an established method to assess stone burden and residual stones.[6] However, the feasibility of reduced fluoroscopy protocols during PCNL has not been widely studied. Decreasing radiation exposure from fluoroscopy during PCNL potentially benefits the patient, surgeon and operating room personnel.

A reduced fluoroscopy protocol was developed and implemented at our institution to decrease radiation exposure. The purpose of this study was to compare fluoroscopy times and treatment outcomes before and after implementing a reduced fluoroscopy protocol during PCNL.

MATERIALS AND METHODS

We performed an institutional review board approved, retrospective chart review of 80 patients at a single academic institution treated with PCNL by a single surgeon between 2007 and 2011. Patients underwent PCNL for large volume renal or staghorn calculi. A total of 40 consecutive patients with complete records who were treated before implementation of the reduced fluoroscopy protocol were compared to 40 consecutive post-protocol patients. Stone burden was assessed preoperatively by CT or plain x-ray of the kidneys, ureters and bladder. Stone cross-sectional area was measured using the largest perpendicular dimension of the stone. Patient demographics, BMI, stone surface area in mm^2, operative time, fluoroscopy time, complication rate, EBL, transfusion rate, hospital stay and success rate were reviewed. Success rate, defined as no fragments 4 mm or greater, was determined by CT done 1 day after surgery. Percutaneous access was obtained by IR before PCNL. Routine consultation with the surgeon who performed PCNL was done for access location. Fluoroscopy time during nephrostomy tube placement was not available for analysis.

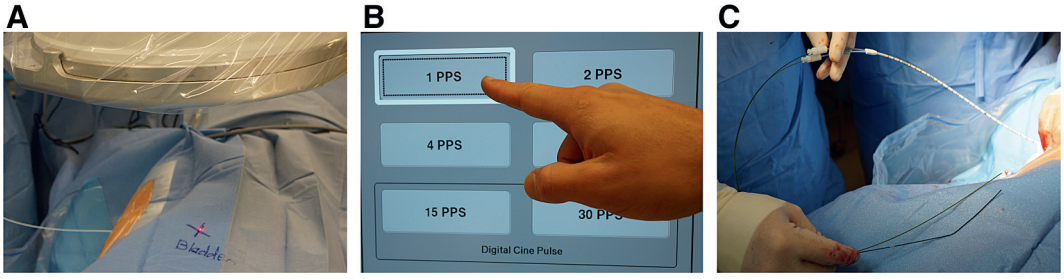
PCNL Technique

PCNL was performed in the operating room with the patient prone and under general anesthesia. Intraoperative fluoroscopy was performed for nephrostogram, tract dilatation, sheath placement, lithotripsy and drainage tube placement. A 22Fr Council tip catheter (Bard®) was placed in the kidney to provide renal drainage and a 5Fr multipurpose angled nephroureteral catheter (Cook® Urological) was placed as a reentry catheter. The 5Fr catheter was routinely removed the morning after surgery if postoperative CT showed no residual stones. The nephrostomy catheter was removed if patients tolerated a 4-hour clamping trial.

Fluoroscopy Reducing Protocol

In the new reduced fluoroscopy protocol we comprehensively reviewed prior imaging immediately before surgery to avoid unnecessary fluoroscopic imaging at the start of the case (see Appendix). Preoperative imaging was displayed on high definition monitors in front of the operating surgeon throughout the case, allowing for intraoperative review of the exact stone location and caliceal involvement. Fluoroscopic imaging was done using an OEC® 9900 Elite portable C-arm machine equipped with laser guidance (fig. 1, *A*). The laser guided C-arm allowed the surgeon to center the unit over the surgical site without using fluoroscopic images for orientation. Also, the C-arm could accurately be moved back and forth between areas of interest which were marked on the drapes, eg kidney and bladder. Fluoroscopy activation was timed at end expiration, the longest, most reproducible period of the respiratory cycle,[7] to minimize image distortion and the need to re-image. This was done with the surgeon observing the respiratory movement and activating fluoroscopy at end expiration or with the assistance of the anesthesiologist providing a verbal cue to hold respiration at end expiration.

Static images obtained during the operation were saved on the secondary screen. Fluoroscopy settings were changed using fixed, lowered mAs and kVp combined with



A, portable C-arm equipped with laser guidance. *B*, changing to single pulse per second fluoroscopy. *C*, substituting fluoroscopic images with visual and tactile cues.