Assessing radiation exposure during endoscopic-guided percutaneous nephrolithotomy

Andrea G. Lantz, MD; Padraic O'Malley, MD;† Michael Ordon, MD, FRCSC;† Jason Y. Lee, MD, FRCSC†*

*Department of Urology, Dalhousie University, Halifax, NS; †Division of Urology, Department of Surgery, St. Michael's Hospital, University of Toronto, Toronto, ON

Cite as: *Can Urol Assoc J* 2014;8(9-10):347-51. http://dx.doi.org/10.5489/cuaj.2037
Published online October 13, 2014.

Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) may be associated with significant ionizing radiation exposure for patients and operating room staff. Endoscopic-guided PCNL (ePCNL) is a technique that may be associated with less radiation exposure. This study examines ePCNL-related radiation exposure (fluoroscopy time, effective dose) and investigates variables that may predict increased exposure.
Methods: A retrospective review of all consecutive ePCNLs performed at our institution, by a single surgeon, was conducted between November 2011 and November 2013. Patient demographics, stone characteristics and perioperative details were recorded, including radiation exposure. Pearson and Spearman correlation were used to assess variables correlated with radiation exposure.
Results: In total, 55 ePCNL cases were included in the study. The mean age was 60 ± 15 years, mean body mass index (BMI) 30.0 ± 6.4 kg/m^2 and mean stone size 3.2 × 2.1 cm. Seven cases (13%) involved complete staghorn stones, and 69% involved supracostal punctures. The mean fluoroscopy time was 3.4 ± 2.3 minutes, mean ED 2.4 ± 1.9 mSv. The treatment success rate, assessed 1-week postoperatively, was 87.3% and 7.3% of cases required ancillary procedures. The overall complication rate was 29%, but only 3 cases (5.5%) were Clavien ≥3. Longer fluoroscopy time correlated with increased stone size ($p < 0.01$), longer operative time ($p < 0.01$) and lower treatment success rates ($p < 0.01$); higher effective dose correlated with longer fluoroscopy time ($p < 0.01$) and increased skin-to-stone distance ($p < 0.01$). BMI did not correlate with fluoroscopy time or effective dose.
Conclusions: Outcomes of ePCNL are comparable to traditional PCNL techniques and may be associated with lower radiation exposure, particularly beneficial for patients with higher BMI.

Introduction

Recent literature has highlighted the potential oncologic significance of excessive diagnostic radiation exposure, both to patients and to healthcare providers, often drawing inferences from atomic radiation studies.[1-7] The use of radiation in the diagnosis and management of stone disease is common and has distinct advantages to other imaging modalities. Exposure to ionizing radiation should be minimized whenever possible.

Since the introduction of percutaneous nephrolithotomy (PCNL),[8] it has become the treatment of choice for large or complex upper tract stones; however, it is also the treatment modality that is potentially associated with the most radiation exposure for patients and surgeons.[9-10] Endoscopic-guided PCNL (ePCNL) is a relatively uncommon approach to PCNL. It was first reported in a series of 9 patients in whom the standard PCNL technique was difficult or had previously failed.[11] ePCNL involves gaining percutaneous access utilizing retrograde, endoscopic assistance via flexible ureterorenoscopy. The advantages of ePCNL include lower transfusion rates, need for fewer access tracts, lower risk of aborting the procedure due to bleeding and shorter operative times.[12] In addition, there may be lower radiation exposure associated with this technique.[12-15] While several studies have examined variables associated with increased radiation exposure during standard PCNL, to our knowledge, no study has been published examining such factors for ePCNL.

The primary objective of our study is to determine patient- and stone-related variables associated with increased radiation exposure (fluoroscopy time and effective radiation dose) during ePCNL. We also compare radiation exposure during ePCNL to published doses associated with standard PCNL techniques.

Methods

A retrospective review was conducted of all consecutive ePCNL procedures performed by a single surgeon (JYL) at our institution from November 2011 to November 2013; ePCNL is the preferred technique utilized by the study's senior author. All patient-related demographic and perioperative details were collected for analysis. All cases were performed using under-table, C-arm fluoroscopy (BV Pulsera, Philips, Netherlands). The total fluoroscopy time (FT) and radiation dosage (dose-area-product) were recorded for the entirety of each case. The dose-area-product (Gy-cm^2) was converted to effective dose (ED) using validated conversion tables.[16]

"Treatment success" was defined as either completely stone-free or the presence of insignificant, asymptomatic fragments measuring <4 mm, for which no further intervention was required. Postoperative imaging was performed 1 week after ePCNL using a computed tomography scan, kidneys-ureters-bladder (KUB) x-ray and/or ultrasonography depending on the clinical circumstances. Patients who had ePCNL in conjunction with other endoscopic treatments (e.g., endopyelotomy) were excluded from the analysis. Operative time was obtained from the surgical operative record from the start time of surgery until the end of the procedure.

Surgical technique

After induction of general anesthesia and endotracheal intubation on a stretcher, patients were carefully positioned into the prone, split-leg position. Scout fluoroscopic images were obtained for radio-opaque stones. A flexible cystoscope was used to cannulate the ipsilateral ureteric orifice with a 5-Fr open-ended catheter (Cook Urological, Bloomington, IN). Following a retrograde pyelogram, a 0.035-inch guide wire was advanced into the renal collecting system. A 10-Fr/50-cm Flexitip dual lumen ureteral access catheter (Cook Medical, Inc.) was then inserted, allowing for the insertion of a 0.038-inch Amplatz extra stiff guidewire (Cook Medical, Inc.), which facilitated the placement of a 9.5/11.5-Fr, 55-cm Flexor ureteral access sheath (Cook Medical, Inc.). Flexible renoscopy was performed with a flexible ureteroscope. Using a combination of air (3-5 cc) and contrast (volume as needed) pyelography, the appropriate calyx was selected for access under direct ureteroscopic vision using the bubbles to help identify the posterior calyces.

Once the calyx was identified, c-arm fluoroscopy (BV Pulsera, Philips, Netherlands) was used to target the calyx for puncture. Standard settings with the automatic kV/mA control with abdominal settings were utilized (automated brightness control, non-pulsed continuous screen, and normal collimation width). Using a standard bullseye technique, an 18-G/15-cm trocar needle was inserted using the tip of the ureteroscope and the air pyelogram as targets. The ureteroscope was used to identify successful calyceal puncture end-on through the papilla. Once access was obtained, an Amplatz extra stiff guide wire was advanced into the collecting system under direct vision, over which an 18-G/5-cm fascial incising needle was used to incise the fascia. The dual lumen ureteral access catheter was then advanced into the collecting system to allow placement of a safety guide wire. All of these steps were performed using endoscopic visualization with minimal or no fluoroscopy.

A 30-Fr Ultraxx dilating balloon with Amplatz sheath (Cook Medical, Inc.) was used for tract dilation and sheath placement, with proper positioning confirmed under direct vision. Lithotripsy was most commonly performed using the Olympus LUS-2 ultrasonic lithotripter. In all cases, fluoroscopic screening and flexible antegrade nephrosocopy was performed to look for residual stone fragments. Retrograde flexible renoscopy was also performed as needed. "Tubeless" (ureteral stent only) PCNL is the standard of care at our institution; nephrostomy tube drainage was employed only when deemed necessary.

Statistical analysis

Patient demographics, stone characteristics and perioperative details were evaluated for correlation with FT and ED. Pearson and Spearman correlation analyses were utilized for continuous and categorical variables, respectively. Stone and operative factors which correlated with treatment success were similarly assessed. SPSS (version 21) was used for all statistical analyses. A p value <0.05 was considered statistically significant.

Results

In total, we reviewed 56 consecutive ePCNL cases. One patient was excluded due to the concomitant antegrade endopyelotomy; therefore, 55 ePCNL patients met the inclusion criteria. No patient required conversion to standard PCNL due to the inability to place a ureteral access sheath and/or to perform flexible renoscopy. Patient demographics and operative data are summarized in Table 1. Three patients had a preoperatively placed nephrostomy tube; however, only 1 previously placed tract was suitable for access. There was no statistical difference in the effective dose and fluoroscopy time for patients with a pre-existing nephrostomy tube; therefore, they were included in the analysis. About half (50.9%) of access tracts were upper pole punctures and 69.1% were supracostal (8.2% supra-11th rib). Only 1 patient required 2 tracts.

Most cases (98%) used "tubeless" PCNL; 1 patient required a nephrostomy tube (the procedure was terminated early by anesthesia due to unrecognized endobronchial tube migration). The mean operative time was 109 ± 45 minutes and the median length of stay was 1 day (interquartile range: 1, 2). Treatment success was 87% 1 week postoperatively. Four patients (7.3%) required ancillary procedures: 3 flexible ureteroscopies for residual fragments and 1 second-look antegrade nephroscopy (nephrostomy tube patient). The overall complication rate was 29.1% (Table 2), with only 5.5% of all complications (3/16) greater than Clavien-Dindo grade

Table 1. ePCNL patient demographics and outcomes data

Variable	
Age, mean (±SD)	60.5 years (14.9)
Male gender (n)	56% (31)
Mean BMI (±SD)	30.0 (6.4)
Mean SSD (±SD)	9.5 (2.4)
ASA score, mean (±SD)	2.6 (0.8)
Mean stone size, cm (±SD)	3.2 (1.1) x 2.1 (0.9)
Left side (n)	58% (32)
Complete staghorn stones (n)	12.7% (7)
FT, mean (±SD)	3.4 mins (2.3)
ED, mean (±SD)	2.4 mSv (1.9)
OR time, mean (±SD)	108.9 mins (45.0)
Type of drainage (n)	
Ureteral stent	98% (54)
NT	2% (1)
Complications (n)	
Overall	29.1% (16)
Grade 1	12.7% (7)
Grade 2	10.9% (6)
Grade 3	5.5% (3)
Length of stay, median (IQR)	1 day (1,2)
Treatment success rate	87.3%
Follow-up imaging (n)	
KUB	49.1% (27)
U/S	10.9% (6)
U/S + KUB	16.4% (9)
NCCT	23.6% (13)
Need for ancillary procedures (n)	7.3% (4)**

ePCNL: endoscopic-guided percutaneous nephrolithotomy; BMI: body mass index; SSD: skin-to-stone distance; ASA: American Society of Anesthesiologists; FT: fluoroscopy time; ED: effective dose; OR: operating room; NT: nephrostomy tube; IQR: interquartile range; NCCT: non-contrast computed tomography; KUB: kidneys-ureters-bladder x-ray; SD: standard deviation; U/S: ultrasound.

2 (2 renal pseudoaneurysms requiring angioembolization, 1 pleural effusion requiring chest tube insertion). There was 1 patient with a small ureteral perforation without subsequent ureteral stricture during follow-up.

The mean fluoroscopy time was 3.4 ± 2.3 minutes, with a mean effective dose of 2.4 ± 1.9 mSv. Longer fluoroscopy time correlated with increased stone size ($p < 0.01$), longer operative time ($p < 0.01$) and lower treatment success rate ($p < 0.01$); higher effective dose correlated only with longer fluoroscopy time ($p < 0.01$) and increased skin-to-stone distance ($p < 0.01$). Patient body mass index (BMI) correlated with neither fluoroscopy time ($p = 0.80$) nor effective dose ($p = 0.17$).

Lower treatment success rate weakly correlated with staghorn stones ($p = 0.03$) and longer operative times ($p < 0.01$). Increased age was associated with complications ($p = 0.03$) and longer hospital admissions ($p < 0.01$). Higher BMI did not correlate with operative time ($p = 0.68$) and only correlated with skin-to-stone distance ($p < 0.01$) and supra-11th rib access location ($p = 0.03$) (Table 3).

Table 2. Complications by Clavien-Dindo grade

Grade	No. complications	Type of complication
Grade 1	7	1 TMJ dislocation during intubation 1 CHF exacerbation 1 SVT 3 acute urinary retention 1 ureteral perforation
Grade 2	6	2 urosepsis 3 delirium 1 COPD exacerbation
Grade 3	3	2 pseudoaneurysm 1 pleural effusion
Grades 4 and 5	0	

CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease; TMJ: temporomandibular joint; SVT: supraventricular tachycardia.

Table 4 compares our cohort with other published FT and ED for both ePCNL and standard PCNL, demonstrating a potential trend towards lower ionizing radiation exposure for ePCNL.

Discussion

Patients with urolithiasis, along with their healthcare providers, may be exposed to significant levels of radiation during both the diagnostic and therapeutic phases of stone management. Researchers have shown that during a primary acute stone event, patients can be exposed to a median of 29.7 mSv, with up to 20% of patients being exposed to >50 mSv during diagnosis and follow-up alone.[17] Such exposure levels, which do not include treatment-related radia-

Table 3. Variables correlated with radiation exposure during ePCNL

Variable	
Fluoroscopy time	
Operative time	$p < 0.001$ (r = 0.494)
Stone size	$p < 0.001$ (r = 0.468)
Treatment success	$p = 0.001$ (r = 0.431)
BMI	$p = 0.803$ (r = 0.035)
Effective dose	
FT	$p < 0.001$ (r = 0.465)
SSD	$p < 0.006$ (r = 0.364)
BMI	$p = 0.170$ (r = 0.191)
BMI	
SSD	$p < 0.001$ (r = 0.648)
Supra-11th rib access	$p = 0.028$ (r = 0.302)
Treatment success	
FT	$p = 0.003$ (ρ = 0.391)
Operative time	$p < 0.001$ (ρ = 0.468)
Staghorn stone	$p < 0.027$ (ρ = 0.301)

ePCNL: endoscopic-guided percutaneous nephrolithotomy; BMI: body mass index; FT: fluoroscopy time; SSD: skin-to-stone distance.

Table 4. ePCNL radiation exposure in the literature

Author (year)	Mean ED (mSv)	Mean FT (min)	Comments
Current study	2.4	3.4	ePCNL
Isac (2013)[15]	NR	3.2 21.1	ePCNL standard PCNL, excluding pre-NT
Blair (2013)[26]	NR	2.93*	standard PCNL *all had NT placed by IR pre-op *does NOT include access-related FT
Lipkin (2012)[22]	7.63 8.11	9.1 6.4	standard PCNL, right side standard PCNL, left side
Ritter (2012)[21]	NR	7.3 6.2	standard PCNL, inexperienced standard PCNL, experienced
Elkoushy (2012)[27]	NR	5.7	standard PCNL
Lipkin (2011)[24]	4.45 7.67	6.9 10.7	standard PCNL, air pyelogram group standard PCNL, contrast pyelogram group
Majidpour (2010)[28]	NR	4.5	standard PCNL, air pyelogram
Mancini (2010)[19]	8.66	NR	standard PCNL
Tepeler (2009)[20]	NR	10.19	standard PCNL

ePCNL: endoscopic-guided percutaneous nephrolithotomy; ED: effective dose; FT: fluoroscopy time; NR: not reported; NT: nephrostomy tube; IR: interventional radiologist.

tion, exceed the International Commission on Radiological Protection recommendation for limits of occupational radiation exposure.[18]

Increased radiation exposure during PCNL has been correlated with high BMI, larger stone burden, longer operative times and surgeon inexperience.[19-21] In our study, longer fluoroscopy time correlated with increased stone size ($p < 0.01$), longer operative time ($p < 0.01$) and lower treatment success rates ($p < 0.01$); these factors may be considered surrogate markers of the degree of surgical difficulty. However, higher effective dose, a more accurate measure of biologically significant radiation exposure than fluoroscopy time alone,[16,22] correlated only with increased skin-to-stone distance ($p < 0.01$); interestingly, we did not find any correlation between BMI and ePCNL-related fluoroscopy time, effective dose or operative time as commonly reported in other studies involving standard PCNL techniques.

Accurately gauging depth of percutaneous needle penetration during PCNL, particularly in obese patients, can be challenging. The needle must be inserted deep enough to enter the collecting system, but without traumatizing the contralateral wall. Once access is gained, accurate advancement of the balloon dilator to the appropriate depth can also be difficult. Flexible ureteroscopy is not affected significantly by patient BMI and provides the surgeon with not only another 3-dimensional point-of-reference during PCNL, but the ability to visually confirm needle and guide-wire placement, to insert dilating devices and to access sheath placement, which may mitigate any effect BMI has on radiation exposure during PCNL. The median BMI of our study population is within the reported range in our geographic area[23] and is comparable to similar PCNL studies reporting BMI.[15,19,20,24]

The mean fluoroscopy time in our study cohort was only 3.4 minutes, which is shorter than most case series using standard PCNL techniques (Table 4), and the mean effective dose of 2.4 mSv in our cohort compares favourably to published reports. For standard PCNL using contrast pyelography, Lipkin and colleagues[24] reported a mean fluoroscopy time about 3 times the amount in our study cohort. In 2010, Mancini and colleagues[19] reported a retrospective review of 96 cases of standard PCNL. The mean effective dose in that study was 8.66 mSv, also over 3 times the mean effective dose within our ePCNL cohort.

Supporting our findings, a recently published retrospective study[15] also reported lower fluoroscopy time with ePCNL with a mean of 3.2 minutes for ePCNL versus 7.3 minutes for the more traditional fluoroscopic-guided access (FGA) group. Their FGA group contained 33 patients with pre-existing nephrostomy tube and, when excluding those patients, the fluoroscopy time was even higher at 21.1 minutes. This study also reported fewer ePCNL cases being terminated due to bleeding obscuring vision (0%) versus 8% in the standard PCNL group, despite groups having similar blood loss and transfusion rates. In our consecutive cohort of 55 patients, not a single case was aborted due to inability to gain access or poor visibility relating to bleeding.

Despite lower radiation exposure, the treatment success rate reported in this study, 87%, is acceptable and compares to the published PCNL literature.[25] The complication rate was relatively high (29%); however, this rate is also comparable to the literature.[25] Most (94%) were minor (Clavien-Dindo grade ≤2) complications, many of which were not directly attributable to the surgical procedure itself (Table 2). No patients required a blood transfusion, and despite 69% of access tracts being supracostal, only 1 patient (1.8%) had a pulmonary complication requiring intervention.

ePCNL does have some drawbacks. This approach requires the use of a flexible ureteroscope (with or without the use of a ureteral access sheath), which may potentially increase the risk of ureteral injury and cost compared to standard PCNL. Two experienced operators are necessary, which may limit its feasibility in certain hospital settings.

This study has several limitations. The single surgeon retrospective methodology, lack of a control group, and the small sample size may limit the generalizability and validity of our findings. There may be differences between our patient population and those of the referenced studies with respect to case complexity, extent of resident involvement and experience of the primary surgeon. These differences may limit the validity of the comparisons between fluoroscopy time and effective dose. Also, as the same c-arm unit was not used in all studies, the comparison of effective dose to published reports may be called into question as this will vary between units and use of the c-arm (i.e., setting, collimation, pulse frequency). Despite these limitations, this study supports the hypothesis that fluoroscopy time is lower with the ePCNL technique. Further prospective, controlled studies are required to determine if there is a true difference in radiation exposure between PCNL techniques; however, the study findings are interesting and hypothesis generating.

Conclusion

This study demonstrates that the ePCNL technique has comparable treatment success and complication rates as standard PCNL techniques with potentially lower radiation exposure. Patient BMI did not correlate with radiation exposure (fluoroscopy time and effective dose) during ePCNL.

Competing interests: Dr. Lantz, Dr. O'Malley, Dr. Ordon and Dr. Lee all declare no competing financial or personal interests.

This paper has been peer-reviewed.

References

1. Pierce DA, Preston DL. Radiation-related cancer risks at low doses among atomic bomb survivors. *Radiat Res* 2000;154:178. http://dx.doi.org/10.1667/0033-7587(2000)154[0178:RRCRAL]2.0.CO;2
2. Davis S, Stepanenko V, Rivkind N, et al. Risk of thyroid cancer in the Bryansk Oblast of the Russian Federation after the Chernobyl power station accident. *Radiat Res* 2004;162:241-8. http://dx.doi.org/10.1667/RR3233
3. Strzelczyk JJ, Damilakis J, Marx MV, et al. Facts and controversies about radiation exposure, Part 1: Controlling unnecessary radiation exposures. *J Am Coll Radiol* 2006;3:924-31. http://dx.doi.org/10.1016/j.jacr.2006.07.009
4. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. *N Engl J Med* 2007;357:2277-84. http://dx.doi.org/10.1056/NEJMra072149
5. Brenner DJ, Elliston CD. Estimated radiation risks potentially associated with full-body CT screening. *Radiology* 2004;232:735. http://dx.doi.org/10.1148/radiol.2323031095
6. Choi KH, Ha M, Lee WJ, et al. Cancer risk in diagnostic radiation workers in Korea from 1996–2002. *Int J Environ Res Public Health* 2013;10:314. http://dx.doi.org/10.3390/ijerph10010314
7. Kuhns LR, Oliver WJ, Christodoulou E, et al. The predicted increased cancer risk associated with a single computed tomography examination for calculus detection in pediatric patients compared with the natural cancer incidence. *Pediatr Emerg Care* 2011;27:345. http://dx.doi.org/10.1097/PEC.0b013e3182132016
8. Fernstrom I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. *Scand J Urol Nephrol* 1976;10:257-9.
9. Jindal T. The risk of radiation exposure to assisting staff in urological procedures: A literature review. *Urol Nurs* 2013;33:136-9.
10. Hellawell GO, Mutch SJ, Thevendran G, et al. Radiation exposure and the urologist: What are the risks? *J Urol* 2005;174:948-52. http://dx.doi.org/10.1097/01.ju.0000170232.58930.8f
11. Grasso M, Lang G, Taylor FC. Flexible ureteroscopically assisted percutaneous renal access. *Tech Urol* 1995;1:39.
12. Sountoulides PG, Kaufmann OG, Louie MK, et al. Endoscopy-guided percutaneous nephrostolithotomy: benefits of ureteroscopic access and therapy. *J Endourol* 2009;23:1649. http://dx.doi.org/10.1089/end.2009.1532
13. Kidd CF, Conlin MJ. Ureteroscopically assisted percutaneous renal access. *Urology* 2003;61:1244-5. http://dx.doi.org/10.1016/S0090-4295(03)00006-2
14. Khan F, Borin JF, Pearle MS, et al. Endoscopically guided percutaneous renal access: "Seeing is believing." *J Endourol* 2006;20:451-5. http://dx.doi.org/10.1089/end.2006.20.451
15. Isac W, Rizkala E, Liu X, et al. Endoscopic-guided versus fluoroscopic-guided renal access for percutaneous nephrolithotomy: A comparative analysis. *Urology* 2013;81:251. http://dx.doi.org/10.1016/j.urology.2012.10.004
16. Le Heron JC. Estimation of effective dose to the patient during medical x-ray examinations from measurements of the dose-area product. *Phys Med Biol* 1992;37:2117. http://dx.doi.org/10.1088/0031-9155/37/11/008
17. Ferrandino MN, Bagrodia A, Pierre SA, et al. Radiation exposure in the acute and short-term management of urolithiasis at 2 academic centers. *J Urol* 2009;181:668. http://dx.doi.org/10.1016/j.juro.2008.10.012
18. Wrixon AD. New ICRP recommendations. *J Radiol Prot* 2008;28:161-8. http://dx.doi.org/10.1088/0952-4746/28/2/R02
19. Mancini JG, Raymundo EM, Lipkin M, et al. Factors affecting patient radiation exposure during percutaneous nephrolithotomy. *J Urol* 2010;184:2373. http://dx.doi.org/10.1016/j.juro.2010.08.033
20. Tepeler A, Binbay M, Yuruk E, et al. Factors affecting the fluoroscopic screening time during percutaneous nephrolithotomy. *J Endourol* 2009;23:1825. http://dx.doi.org/10.1089/end.2009.0256
21. Ritter M, Siegel F, Krombach P, et al. Influence of surgeon's experience on fluoroscopy time during endourological interventions. *World J Urol* 2012;31:183-7.
22. Lipkin ME, Mancini JG, Toncheva G, et al. Organ-specific radiation dose rates and effective dose rates during percutaneous nephrolithotomy. *J Endourol* 2012;26:439-43. http://dx.doi.org/10.1089/end.2011.0178
23. Dutton DJ, McLaren L. Explained and unexplained regional variation in Canadian obesity prevalence. *Obesity* 2011;19:1460. http://dx.doi.org/10.1038/oby.2010.339
24. Lipkin ME, Mancini JG, Zilberman DE, et al. Reduced radiation exposure with the use of an air retrograde pyelogram during fluoroscopic access for percutaneous nephrolithotomy. *J Endourol* 2011;25:563. http://dx.doi.org/10.1089/end.2010.0431
25. de la Rosette J, Assimos D, Desai M, et al. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: Indications, complications, and outcomes in 5803 patients. *J Endourol* 2011;25:11. http://dx.doi.org/10.1089/end.2010.0424
26. Blair B, Huang G, Arnold D, et al. Reduced fluoroscopy protocol for percutaneous nephrostolithotomy: Feasibility, outcomes and effects on fluoroscopy time. *J Urol* 2013;190:2112-6. http://dx.doi.org/10.1016/j.juro.2013.05.114
27. Elkoushy MA, Shahrour W, Andonian S. Pulsed fluoroscopy in ureteroscopy and percutaneous nephrolithotomy. *J Urol* 2012;79:1230-5. http://dx.doi.org/10.1016/j.urology.2012.01.027
28. Majidpour HS. Risk of radiation exposure during PCNL. *Urol J* 2010;7:87-9.

Correspondence: Dr. Jason Y. Lee, 61 Queen St. East, Suite 9-103, St Michael's Hospital, Toronto, ON M5C 2T2; leejasoSMH@gmail.com