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ORIGINAL ARTICLE

Does the presence of a percutaneous renal access influence fluoroscopy time during percutaneous nephrolithotomy?

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Abstract *Objective:* The aim of this study was to assess whether the presence of a pre-formed percutaneous renal access (PCA) had any effects on fluoroscopy time (FT) during percutaneous nephrolithotomy (PCNL).
Methods: After ethics approval was obtained, medical records of all patients who underwent PCNL between 2009 and 2013 at a tertiary stone referral centre were retrospectively reviewed. Patients with and without pre-formed PCA undergoing PCNL were compared. Patients who underwent second-look PCNL and those who had their access inserted by interventional radiology constituted the group with pre-formed PCA.
Results: A total of 185 PCNLs were reviewed. The mean patient age was 55.2 ± 1.0 years with mean body mass index (BMI) of 27.8 ± 0.5 kg/m^2 and male gender of 63.8%. The mean stone size was 618.4 ± 47.0 mm^2 with mean Guy's grade of 2.3 ± 0.7 and mean S.T.O.N.E. score of 7.6 ± 0.1. The mean operative time was 98.7 ± 2.6 min with mean FT of 113.4 ± 4.5 s. The overall stone-free rate was 71.9% with complication rate of 16.2%. When compared with PCNLs without pre-formed PCA, PCNLs with pre-formed PCA were associated with significantly shorter FT (120.6 ± 5.1 *vs.* 77.5 ± 6.7 s; $p < 0.001$) and significantly lower estimated blood loss (EBL) ($p = 0.01$). On multivariate analysis, PCNLs with pre-formed PCA were associated with significantly shorter FT (B. coefficient = −43.2 (95%CI: −66.4 to −20); $p < 0.001$) and lower EBL ($p = 0.02$).

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Conclusion: PCNLs with pre-formed PCA were associated with significantly lower FT and EBL when compared with PCNLs without pre-formed PCA.

1. Introduction

According to the latest American Urological Association guidelines on staghorn stones, fluoroscopically-guided percutaneous nephrolithotomy (PCNL) is still the cornerstone of treatment of large renal stones [1]. However, it is associated with the highest radiation exposure compared with other endourological procedures [2,3]. Although ionizing radiation offers advantages over other imaging modalities, patients and medical personnel may be exposed to significant levels of radiation. Some authors have even reported potential oncologic consequences from exposure to excessive ionizing radiation [4—6]. Thus, the need for following radiation safety measures including minimizing amount of fluoroscopy during PCNL and wearing appropriate radiation protective gear [3,7].

Several studies have already determined factors associated with increased radiation exposure during PCNL [8—10]. However, there is a paucity of literature regarding the effect of presence or absence of percutaneous renal access (PCA) on fluoroscopy time during PCNL. Therefore, the aim of this study was to assess whether PCNLs with pre-formed PCA are associated with significantly shorter fluoroscopy time (FT) when compared with PCNLs without pre-formed PCA.

2. Patients and methods

2.1. Study design

This study was conducted in concordance with the declaration of Helsinki 2013 and after approvals from the Director of Professional Services and Ethics Board of McGill University Health Centre (No. 14-050-GEN) were obtained. A retrospective review of all consecutive PCNLs between 2009 and 2013 was performed. Both Guy's and S.T.O.N.E. nephrolithometry scores were calculated. All PCNLs were performed by a single fellowship-trained endourologist (SA) under general anesthesia. Except for seven PCNLs performed in the supine position, all PCNLs were performed in the prone position according to what has been previously published [11,12]. At the end of the procedure, an antegrade indwelling 6F double-pigtail ureteral stent was inserted. In addition, a 20F council-tip Foley catheter was used as a nephrostomy tube for standard PCNL cases. For tubeless PCNL cases, the skin was closed with 4-0 absorbable suture. Immediately post-operatively, the attending endourologist filled out PCNL datasheets containing patients' pre-operative information and intra-operative procedural details. All of the PCNL datasheets and patients' medical charts were reviewed. Patients were followed up with plain radiographs (kidney-ureter-bladder) at 1 and 3 months. Non-contrast computed tomography (NCCT) scans were obtained for patients with radiolucent stones. Stone-free was considered in cases with absence of any stones or presence of clinically insignificant residual fragments ($<$4 mm) at follow-up. The intra-operative estimated blood loss (EBL) was categorized as $<$250 mL or $\geq$250 mL. FT was calculated from the beginning till the end of the case including cystoscopy and retrograde pyelography. The calculation method for the FT has been previously reported [10]. Post-operative complications were reported according to the modified Clavien classification system [13]. PCNLs were categorized into two groups according to the presence or absence of pre-formed PCA. Therefore, the first group included PCNLs without pre-formed PCA, where the PCA was performed using fluoroscopic-guidance by the attending endourologist at the time of PCNL. The second group included PCNLs with pre-formed PCA, where the PCA had been inserted prior to the PCNL during either a previous PCNL procedure for patients undergoing second-look PCNLs or the PCA was inserted by an interventional radiologist (IR) under ultrasound- or CT-guidance. There were several indications for patients having their PCA by an IR prior to PCNL. These indications included patients with: renal transplant stones; severe scoliosis; ankylosing spondylitis; encrusted indwelling ureteral stents with renal, ureteral and bladder stones; quadriplegia and spinal fixation with metal rods overlying the kidneys; urinary diversions; pelvic kidneys; and patients with retro-renal colons.

2.2. Statistical analysis

Both groups were compared in terms of baseline demographics and peri-operative outcomes. FT and continuous variables were compared between the two groups using the Mann Whitney-*U* test. Categorical variables were compared using Fisher's exact test or Chi-square test. Two tailed *p*-values <0.05 were considered statistically significant. Multivariate logistic regression analysis and general linear models were performed to estimate the effect size and correct for any possible confounders. SPSS for Windows version 20 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

3. Results

A total of 185 PCNLs were identified and reviewed. The mean patient age was 55.2 $\pm$ 1.0 years with a mean body mass index (BMI) of 27.8 $\pm$ 0.5 kg/m^2 and male gender of 63.8% (118/185). The mean stone size was 618.4 $\pm$ 47.0 mm^2 with mean Guy's grade of 2.3 $\pm$ 0.7 and

mean S.T.O.N.E. score of 7.6 ± 0.1. The mean operative time was 98.7 ± 2.6 min with mean FT of 113.4 ± 4.5 s. The overall stone-free rate was 71.9% (133/185) with complication rate of 16.2% (30/185). According to the modified Clavien classification, complications are reported as follows: Grade 1: 6 (3.2%); Grade 2: 9 (4.9%); Grade 3a: 2 (1.1%); Grade 3b: 11 (5.9%); and Grade 4b: 1 (0.5%). There were no Grade 4a or Grade 5 complications. EBL of ≥250 mL occurred in 53 (28.6%) PCNLs. Tubeless PCNL was performed in 47.0% (87/185) of PCNLs. The mean length of hospital stay (LOS) was 4.09 ± 0.2 days.

When compared with PCNLs without pre-formed PCA, PCNLs with pre-formed PCA were completed with significantly shorter FT (120.6 ± 5.1 *vs.* 77.5 ± 6.7 s; $p < 0.001$) and there were significantly less patients with EBL of ≥250 mL (50 (32.3%) *vs.* 3 (10.0%); $p = 0.01$) (Table 1). However, there was no significant difference between the two groups in terms of patient age (56.3 ± 2.6 *vs.* 55.0 ± 1.2 years; $p = 0.74$), female gender (12 (40.0%) *vs.* 55 (35.0%); $p = 0.68$), BMI (29.8 ± 1.5 *vs.* 27.4 ± 0.5 kg/m^2; $p = 0.16$), stone size (662 ± 149 *vs.* 610 ± 48 mm^2; $p = 0.58$), right-sided stones (15 (50.0%) *vs.* 66 (42.6%); $p = 0.55$), mean Guy's grade (2.1 ± 0.2 *vs.* 2.3 ± 0.1; $p = 0.58$), mean S.T.O.N.E. score (7.5 ± 0.3 *vs.* 7.7 ± 0.1; $p = 0.62$), operative time (92.0 ± 5.9 *vs.* 100.1 ± 2.3 min; $p = 0.25$), stone-free status (22 (73.3%) *vs.* 111 (71.6%); $p = 0.99$) and post-operative complications (6 (20.0%) *vs.* 24 (15.5%); $p = 0.59$) (Table 1). In addition, there was no significant difference between tubeless and standard PCNLs in terms of FT (120.3 ± 7.4 *vs.* 107.7 ± 5.5 s; $p = 0.17$). On multivariate analysis, PCNLs with pre-formed PCA were associated with significantly shorter FT (B. coefficient = −43.2 (95%CI: −66.4 to −20); $p < 0.001$) and significantly lower risk of having EBL of ≥250 mL (OR = 0.2 (95%CI: 0.07 to 0.8); $p = 0.02$).

Table 1 Comparison of baseline demographic characteristics and peri-operative outcomes between the two groups.

Variable	Pre-formed PCA		*p*-Value
	Yes ($n = 30$)	No ($n = 155$)	
Age (year)	56.3 ± 2.6	55.0 ± 1.2	0.74
Female gender	12 (40.0)	55 (35.5)	0.68
Right sided stones	15 (50.0)	66 (42.6)	0.55
BMI (kg/m^2)	29.8 ± 1.5	27.4 ± 0.5	0.16
Stone size (mm^2)	662 ± 149	610 ± 48	0.58
CT Hounsfield units	922 ± 65	881 ± 25	0.63
Radiolucent stones	6 (20.0)	19 (12.8)	0.39
Guy's grade	2.1 ± 0.2	2.3 ± 0.1	0.58
S.T.O.N.E. score	7.5 ± 0.3	7.7 ± 0.1	0.62
Operative time (min)	92.0 ± 5.9	100.1 ± 2.3	0.25
Fluoroscopy time (s)	77.5 ± 6.7	120.6 ± 5.1	<0.001
Tubeless PCNLs	14 (46.7)	73 (47.1)	0.99
PCNLs with EBL ≥250 mL	3 (10.0)	50 (32.3)	0.01
Stone-free rate	22 (73.3)	111 (71.6)	0.99
Post-operative complications	6 (20.0)	24 (15.5)	0.59
Length of hospital stay (day)	3.9 ± 0.7	4.1 ± 3.3	0.42

Data of continuous variables were presented as mean ± SE and categorical variables as number and percentage (*n*, %). PCA, percutaneous renal access; BMI, body mass index; PCNL, percutaneous nephrolithotomy; EBL, estimated blood loss.

4. Discussion

In the current study, when compared with PCNLs without pre-formed PCA, PCNLs with pre-formed PCA were associated with significantly shorter FT (120.6 ± 5.1 *vs.* 77.5 ± 6.7 s; $p < 0.001$) and there were significantly less patients with EBL of ≥250 mL (50 (32.3%) *vs.* 3 (10.0%); $p = 0.01$). Although this may seem obvious, this study is the first to document the effect of pre-formed PCA being associated with significantly less fluoroscopy and thus radiation when performing fluoroscopically-guided PCA during PCNL. While previous studies have looked at several determinants of FT during PCNL, the presence or absence of a PCA has not been previously examined. For example, increased stone burden and multiple access tracts have been associated with significantly prolonged FT while elevated BMI, increased stone burden and multiple access tracts have been associated with significantly higher effective radiation doses [8,9]. Furthermore, a recent study by Noureldin et al. [10] found that operative time, EBL and number of punctures were the only predictors of FT during PCNL on multivariate analysis. However, the effect of pre-formed PCA on FT was not studied. Since in the present study patients with pre-formed PCA were compared with patients without pre-formed PCA, it was not logical to compare the number of punctures between the two groups; the group with pre-formed PCA would have zero punctures. Therefore, the two other predictors of PCA, namely operative time and EBL, were examined. While there was no significant difference between the two groups in operative time, patients with pre-formed PCA were associated with significantly less EBL (Table 1). Others have concentrated their efforts of minimizing FT using the different functions of the C-arm fluoroscopy unit. For example, it has been reported that by using pulsed fluoroscopy at 4 frames per second was associated with 65% decrease in FT during PCNLs (341.1 *vs.* 121.5 s; $p = 0.001$) when compared with PCNLs performed using standard fluoroscopy at 30 frames per second [14]. In the present study, all PCNL cases since November 2010 were performed using pulsed fluoroscopy to minimize FT. Another group of investigators have further adjusted the settings of the C-arm unit to further reduce FT during PCNLs. Using visual and tactile cues, fixed lower mAs and kVp, a designated fluoroscopy technician on a laser-guided C-arm, and pulsed fluoroscopy at 1 frame per second was associated with 80.9% reduction in FT during PCNLs (175.6 *vs.* 33.7 s; $p < 0.001$) [15]. Finally, endoscopic-guided PCA has been recently described to be associated with significantly lower FT during PCNL [16,17].

The second finding of the current study was that PCNLs with pre-formed PCA were associated with significantly less patients with EBL of ≥250 mL. This is consistent with the findings of the study by Kukreja et al. [18], where they found that EBL was significantly lower in patients with mature nephrostomy tracts.

Limitations of the present study could be addressed as follows. First, the retrospective nature is a point of weakness. However, FT for every PCNL was collected prospectively and documented in PCNL datasheets immediately post-operatively by the attending endourologist. Second, FT during the PCA portion of PCNL was not specifically marked on the datasheets. Third, the EBL was estimated as a categorical variable $<$250 mL *vs.* $\geq$250 mL. Nevertheless, this is the first study to report the size effect of a pre-formed PCA on both FT and EBL during PCNL.

5. Conclusion

PCNLs with pre-formed PCA were associated with significantly lower FT and EBL when compared with PCNLs without pre-formed PCA. This highlights the significant impact of the presence of a PCA on both FT and EBL.

Conflicts of interest

The authors declare no conflict of interest.

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