Radiation exposure during percutaneous nephrolithotomy; Is there a risk of the patient and the operating team?

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► ***Short report***

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ABSTRACT

Background: The aim of this study was to calculate the radiation amount exposed during percutaneous nephrolithototomy (PCNL) and to make the urologists and other staff sensitive about the radiation risk they were exposed to. ***Materials and Methods***: We measured the radiation exposure during 114 cases of PCNL performed. Thermoluminescent dosimeters (TLD) were placed between the operation table and the patient at the location of kidney and gonads of patients to measure the radiation exposure of patients. TLD were placed at the head, neck, finger and the legs of the operating surgeon to measure the occupational exposure of the urologist. And also two dosimeters were placed to the inner wall of the operating room and two dosimeters were placed to the hall. ***Results:*** The mean fluoroscopy screening time was 2.18 minutes (0.15 - 6.12) and the mean operation time was 49 minutes (10-150). The mean radiation exposure for patients was 1.307 milisievert (mSv) at kidney location and 0.562 mSv at gonad location per procedure. Surgeon exposure was 0.021 and 0.003 mSv per procedure for hand and leg, respectively. Radiation amounts exposed inside the room and by the surgeon were statistically significantly lower than measured radiation results compared to patient kidney. ***Conclusion:*** According to our findings radiation exposure of the patient and the surgeon is below the annual occupational dose limit recommendations. However, for protecting from stochastic effects of radiation, fluoroscopy should be used as low as possible and lead aprons and thyroid shields must be worn to minimize the radiation exposure.

Keywords: *Percutaneous nephrolithototomy, radiation exposure, urolithiasis.*

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INTRODUCTION

Urolithiasis is one of the urological diseases seen quite often. Its current prevalence is accepted as 1-20% [(1)]. Urinary system stone disease incidence, the yearly cost of which reaches 2 billion dollars in USA, increases every day and the changing life standards, obesity, changes in nutrition habits are accepted as the main factors blamed for this increase. Turkey is accepted as one of the endemic countries in both the adult and child patient group in the world on this subject [(2,3)].

Since the introduction of percutaneous nephrolithotomy (PCNL), 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 [4].

Fluoroscopy is typically performed during PNL to guide percutaneous access and evaluate for residual stone. However, fluoroscopy use in the clinical setting signifies exposure to ionizing radiation [5]. Due to common use of fluoroscopy, urologists and operation room staff are under the occupational risk of radiation exposure.

The aim of this study was to calculate the radiation exposed during PNL and to make the urologists and other staff sensitive about the radiation risk they are exposed to.

MATERIALS AND METHODS

Patient choice and surgical technique

One hundred fourteen patients who had percutaneous nephrolithototomy (PCNL) were included in the study. Patients were radiologically evaluated with intravenous pyelography (IVP) and/or uncontrasted computer tomography (CT) before the operation. Age and gender of the patients, location and dimension of the stone, surface area, operation duration, scopy duration, access number, presence of residual stone information were also recorded.

6F ureteral catheter was located in all patients in lithotomy position under general anesthesia. The patient was taken to the prone position after installing foley catheter. After contrast material was given from ureteral catheter following appropriate field cleaning and covering, pelvicalyceal structures were evaluated under fluoroscopy and posterior calyx was entered with 18 gauge translumbar angioplasty (TLA) needle (Boston Scientific, Natick, MA, USA). By sending 0.035 in sensor guidewire (Boston Scientific, Natick, MA, USA) to the collecting system inside TLA needle, dilatation was made with amplatz dilatators, metal dilatators or baloon dilatators over the guide. Stones were extracted after breaking up the stones by entering the collecting systems with nephroscope (Karl Storz Gmb H&Co, Tuttlingen, Germany) after appropriate dilatation. After the operation, nephrostomy tube was located in every patient and the presence of any residual stones was checked with scopy. Mobile multiway C armed fluoroscopy (Ziehm 8000, Nuremberg, Germany) device with X-ray tube below was used in these operations. Fluoroscopy device had automatic brightness control mode automatically adjusting optimum tube voltage and current according to the weight of the patient. During operations, all operating room staff wore thyroid protecting neck collar and lead apron for protection from radiation.

Radiation measurement

Thermoluminescent dosimeter 100 (TLD100) was used to measure radiation. In order to measure the absolute dose given to TLDs, TLDs were calibrated with Cobalt-60 to determine the relation between TLD reading and absorbed amount. In order to measure radiation exposure of the patients, TLD100 was located between the operation table and the patient to fit in the kidney and gonad areas and in order to measure surgeon radiation exposure, in the forehead area, neck and ring finger of the surgent. Also two dosimeters were located both 250 cm away from C-armed fluoroscopy device and 400 cm and 500 cm away outside the room in order to measure radiation in the operation room environment. Dosimeters were evaluated once in every two months. When TLD100 are heated up to high temperatures, they spread a visible light in proportion to the radiation amount they absorb. This light can be measured with a photomultiplier tube and radiation dose is calculated. After being heated up to 50 °C first, dosimeters were heated up to 300 °C with a rate of 25 °C per second and keeping 13.3 seconds at 300 °C, the radiation dose was calculated.

Consent was taken from local ethic board (Keçiören Training and Research Hospital Ethic Board, No: 2011-238) for this study in line with Helsinski Declaration.

Statistical analysis

Statistical analysis was performed with SPSS, v.15.0 statistical software (SPSS, Inc., Chicago, IL, USA). Doses exposed to in different areas where radiation was measured were compared using

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Mann-Witney U-test and Kruskal Wallis H-test and it examined with Spearman Rho test to see whether there was a correlation.The level of significance was predetermined as $P < 0.05$.

RESULTS

One hundred fourteen patients, 43 females (37%) and 72 males (63%), had PCNL. Mean age of the patients was 41.8 (3-79) years. 6 patients under 16 years of age had PCNL. In pediatric patients, the parts outside the kidney location of the patients were protected with a lead apron in order to decrease the radiation exposure of lungs and gonads during the operation. Mean stone surface area was 501 mm^2 (82-5895). Operation duration was 49 minutes (10-150). Mean scopy duration was 138 seconds (15-372). The stones of 92 patients were completely cleaned and 80.7% ratio of no stones was acquired. PCNL operation was made in the prone position in all of the patients and nephrostomy tube was located in all of the patients. Access number was 1.078 in average. PCNL patient demographics and outcomes data are shown on table 1.

Table 1. PCNL patient demographics and outcomes data.

Age, mean (±SD)	41.8years (12.6)
Male gender (n)	(63) % 72
Mean BMI (±SD)	(5.2) 28.1
Mean stone surface area (mm$^{2)}$ (±SD)	(296) 501
Stone localization (n)	
Pelvis	39,5% (45)
Lower calyx	26,3% (30)
Partial staghorn	18,5% (21)
Staghorn	10,5% (12)
Upper-medium calyx	5,2% (6)
Operation duration (minutes) (±SD)	(32) 49
Mean scopy duration (seconds) (±SD)	(96) 138
Complete stone free rate (n)	%80.7 (92)

While mean radiation exposure of the patients per case was found 1.307 milisievert (mSv) in kidney location, it was found 0.562 mSv in gonad location. And the hands taking 0.021 mSv radiation per case were found as the most radiation-exposed parts of the operator. While radiation exposure of the feet was found 0.003 mSv per case, the radiation was under the measurable dose (<0.1 mSv) in 6 month period in dosimeters located in the forehead and neck area. Exposure below the measurable dose was also detected in the dosimeters located inside the operation room and hall. According to the dosimeter results for each case and measured every six months, it was observed that the radiation amount exposed by the surgeon in areas where radiation was measured was statistically significantly lower when compared to the radiation dose measured in patient kidney. ($p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$ respectively) Similarly when the measured radiation amount exposed to inside and outside the operation room was compared to patient kidney, it was calculated that 6-month dosimeter results were statistically significantly low. ($p<0.001$, $p<0.001$ respectively) It was also detected that the radiation dose in patient kidney and in Surgeon Hand, Surgeon Foot and Patient Gonad had a correlated increase. Dosimeter results and mean radiation exposured per case is shown in table 2.

Table 1. PCNL patient demographics and outcomes data.

Areas where the radiation is measured	Dosimeter results (6 months) ± SD (mSv)	p Value	Mean radiation exposure per case ± SD (mSv)	p Value
Surgeon Forehead	<0.1	<0.001	<0.001	<0.001
Surgeon Neck	<0.1	<0.001	<0.001	<0.001
Surgeon Hand	1.19 ± 2.43	<0.001	0.001 ± 0.021	<0.001
Surgeon Foot	0.16 ± 0.45	<0.001	0.001 ± 0.003	<0.001
Patient kidney	**41 ± 149**		**0.42 ± 1.307**	
Patient Gonad	64 ± 16	<0.001	0.13 ± 0.562	<0.001
Operation Room Inside	<0.1	<0.001	---	
Operation Room Outside	<0.1	<0.001	---	

*mSv:milisievert

DISCUSSION

Fluoroscopic imaging is used commonly in urology practice. Due to cumulative radiation exposure, urologist and auxiliary staff are under the risk of radiation damage. Collimation of X ray prevents direct radiation exposure of urologist and auxiliary staff but absorbing radiation during the operation, the patient becomes a second radiation source[5]. That is why measuring radiation exposure of the patients and the staff is important not to exceed the safe dose of radiation.

Biological effects of radiation exposure are separated into two groups as stochastic and deterministic effects. Severity of deterministic effects increase with the dose. There is no border dose for stochastic effects. There is no relation between dose and radiation effects. The possibility of the effect occuring increases with the dose. Cancer induction and genetic effects are among stochastic effects. International Commission on Radiation Protection (ICRP) defined occupational dose limit as 20mSv as the yearly average which should be lower than 50 mSv in any year in a five year period. JCRP similarly suggested that the yearly limit should be less than 150 mSc for eye lens, 500 mSv for the skin and 500mSv for extremities. But there is no dose limit determined for the patients who have been exposed to radiation during diagnosis and treatment phase [6].

Fluoroscopy is used to provide access during PCNL and its use in PCNL is not limited to access only. It is used in locating guide and dilatation of nephrostomy tract. It is used in evaluation of residual stone presence after lithotripsy and verifying that nephrostomy tube or ureteral stent is in the appropriate place.

Ultrasonography (USG) use during PCNL is a good way to decrease radiation exposure. The reason for USG having a limited area of use is the fact that it is user dependent, requires experience and especially the difficulty in seeing the stone and ureter when locating the guide during access. In studies on this subject, it was reported that USG use in PCNL is a good method in uncomplicated, large renal pelvis stones in which renal cavity is enlarged [7,8].

The increase in body mass index (BMI), stone load and access number in different studies causes an increase in radiation dose [9,10]. In a study on 60 patients, it was reported that mean scopy duration was 24 minutes and the urologist was exposed to 0.1 mSv radiation in average. It was observed that patient radiation exposure was 250 mSv in kidney location, 4.40 mSv in female genital area and 1.20 mSv in male genital area [9]. Rao et al showed in a study made in 1987 that the mean scopy duration was 21.9 minutes and abdominal radiation exposure of patients was 10.2 mSv. Since providing access and dilatation operations are made by the radiologist, radiation exposure in the hand and fingers of the radiologist was found higher than the exposure of the urologist. While radiation exposure was 3.8 mSv and 5.8 mSv in order for hands and fingers of the radiologist, it was reported that radiation exposure for the hands and fingers of the urologist was 1.4 mSv and 1.7 mSv in order. The scopy duration in both studies is much over the average [11].

Bowsher et al showed in a study made in 1992 that mean scopy duration was 2.0 minutes, radiation exposure was 0.12 mSv for the forehead and 0.14 mSv for the hand [12].

Hellawel *et al.* showed in a study made in 2005 that mean scopy duration was 1.18 minutes and radiation exposure was 11.6 mSv, 6.4 mSv, 1.9 mSv and 2.7 mSv in order for leg, foot, eye and hands [13].

Kumari *et al.* reported in a study made in 2006 that mean scopy duration was 6.04 minutes, patient radiation exposure was 0.56 mSv in kidney location and urologist hand exposure was 0.28 mSv and hand exposure of the urology assistant was 0.36 mSv in their study on 50 patients. They attributed the high radiation exposure of the assistant to fluoroscopy use when locating the ureteral catheter [14]. Fluoroscopy is not used during ureteral catheterization in our clinic. So scopy duration is shortened.

In the published study of Majidpour on 100 cases (2010), the mean scopy duration was reported as 4.5 minutes and radiation exposures of urologist in order for head, eye, hand and foot were 0.47 μGy, 0.04 μGy, 0.21 μGy and 4.1 μGy (1 microgray = 0.001 millisievert) [15].

Lipkin *et al.* (2011) compared patients who had PCNL using contrast and air. In the group of patients who had PCNL by giving contrast, the scopy duration was 642 seconds, radiation exposure of patients was 7.58 mSv and scopy duration in the group of patients who had PCNL by giving air was 411 seconds and the radiation exposure of the patients was 5.25 mSv [16].

Mut Şafak et al showed in a study made in 2009 that mean scopy duration was 12 minutes and the radiation exposure of the urologist was μGy, 33.5 μGy and 48 μGy for eye, hand and neck in order (1 micrograу = 0.001 millisievert) [17].

In our study the mean scopy duration for PCNL was calculated as 2.18 minutes. When compared to other studies in literature, it was observed that our mean scopy duration was shorter. In our study, radiation dose the surgeon's hands were exposed to per case was calculated as 0,021 mSv and the radiation dose the feet of the surgeon was exposed to was calculated as 0,003 mSv. The radiation exposure in forehead and neck area was observed under 0.1 mSv for a period of six months. It was observed that radiation exposure decreased with scopy time. This study demonstrated that the surgeon and operation room staff are under minimal risk of radiation exposure during PNL application. The radiation exposure amount for the patient was detected low when compared to other studies.

BMI decrease in the patient who will have PCNL, avoiding multiple access formation and low stone load, is effective in decreasing radiation dose. USG accompanied and air contrasted PCNL, endoscopic aided PCNL, minimally invasive PCNL, retrograde intrarenal surgery are alternative surgical techniques decreasing radiation [18]. That is why we believe that it is necessary to consider which procedure can be applied in which patient.

In a current study made, it was determined that the fluroscopy duration and the dose of radiation taken decreased in endourological cases after providing radiation security and fluoroscopy education procedures to the health professionals [19].

That is why we think that providing staff education in this area would be helpful in lowering radiation dose [20].

CONCLUSION

According to our findings radiation exposure of the patient and the surgeon is below the annual occupational dose limit recommendations. A substantial source of radiation dose taken by the operator is the radiation from the patient. So staying a few steps away during scopy would substantially decrease the radiation dose taken. The operation room staff should wear lead apron and thyroid protecting collar and the surgical team should wear lead gloves and glasses in addition to

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these. People other than those in the surgical team should stay 1 meter away from the X-ray source. We think that providing radiation security and fluoroscopy education procedures and choosing the appropriate procedure for surgery would also be effective in decreasing the radiation amount taken.

Conflicts of interest: *Declared none.*

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