Risk of Radiation Exposure During PCNL

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Purpose: Fluoroscopic guidance is a routine practice in endourology; both the physician and the assistances are exposed to some radiation via radiation scatter. Measurement of radiation doses in staff is important, but often these data are not reported.

Materials and Methods: We measured radiation exposure during 100 cases of percutaneous nephrolithotomy using lithium fluoride thermoluminescent dosimeters placed at the head, eye glasses, the fingers, and the legs of the operating surgeon, the assistant, and the circulating nurse.

Results: The mean screening time was 4.5 minutes (range, 1 to 8 minutes) with mean fluoroscopy tube potential of 73 kVp, and mean tube current of 2.8 mA. The estimated scatter exposure rate at 40 cm from the x-ray beam was 0.47, 0.04, 0.21, and 4.1 µGy to the head, eye glasses, the fingers, and the legs of the operating surgeon, respectively. The estimated scatter exposure rate at different points from the x-ray beam was 0.05, 0.01, 0.025, and 0.1 µGy to the head, eye glasses, the fingers, and the legs of the assistant, respectively and the estimated scatter exposure rate at all different points from the x-ray beam for circulating nurse was 0 µGy.

Conclusion: Fluoroscopic screening results in radiation exposure of the medical staff. The surgeon received the maximum radiation exposure, mostly to the legs and very least to the eyes. The assistant received less radiation exposure than the surgeon and the nurse did not receive significant amount of radiation.

Keywords: operating rooms, radiation, percutaneous nephrolithotomy

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a common urologic practice for treatment of upper urinary tract calculi, tumors, and stricture. The practice of PCNL, having been refined over time, continues to evolve and has largely replaced open stone surgery for the treatment of complex upper tract calculi unsuitable for extracorporeal shockwave lithotripsy or ureteroscopy, resulting in stone removal with less morbidity, shorter convalescence, and reduced cost compared with open surgery. (1,2) Fluoroscopic guidance is the preferred technique for most of the stone therapies with PCNL. As endourology has become an important practice of urology, the use of fluoroscopic guidance has increased the exposure of urologists to the possibly deleterious effects of radiation. (3) The radiation exposure of staff increases due to scattered radiation produced from interaction of the primary radiation beam with the patient and the operating table. The medical staff standing next to the C-arm fluoroscopy unit are subjected to receive scatter radiation from all directions. The lower and
upper extremities are in radiation risk. Standard radiation protection protocol requires the use of 0.35 mm lead aprons and thyroid shields for the operating surgeon and 0.25 mm lead aprons for other operating room staff. The aprons and shields reduce transmission by 100-fold or more and hence gonadal and thyroid doses are minimal. In this study, we attempted to evaluate the doses of radiation received by the operating room personnel during PCNL at endourology centers to assess the radiation risk and the radiation exposure rate at different parts of the body.

MATERIALS AND METHODS
One hundred patients underwent PCNL. The patients were placed initially in a lithotomy position for retrograde ureteral catheter placement in the renal pelvis/superior calyx on the stone bearing side under fluoroscopic guidance. Thereafter, the patient was placed in a prone position and the location of the stones in the kidney was confirmed using air contrast instilled via the ureteral catheter. The operating urologist established the tracts by puncturing the desired calyces and dilating the tracts under fluoroscopic guidance. Stone fragmentation was performed using pneumatic lithotripsy and the fragments were removed with stone grasping forceps. At the end of the procedure, fluoroscopic screening of the renal area was performed to ensure stone clearance using a mobile multidirectional C-arm fluoroscopy unit with an under the couch x-ray tube and an over the couch image intensifier (SHIMADZU OPESCOPE 50 N, Japan). The fluoroscopy unit has a combined energy/current (kVp/mAmp) selector, which controls the radiation output at the tube and an Automatic Brightness Control (ABC) mode, which selects the optimal tube voltage and current, automatically.

The urologist wore lead aprons, thyroid shields (0.5 mm equivalent lead thickness) (Meditronics, Iran), and lead glasses during the entire procedure. Other operating room staff wore lead aprons and thyroid shields (0.5 mm equivalent lead thickness) (Meditronics, Iran).

To measure the radiation exposure, lithium fluoride thermoluminescent dosimeter chips (TLDs) have been placed at the head, eyeglasses, the fingers, and the legs of the operating surgeon, the assistant, and the circulating nurse. Thermo luminescent dosimeter chips were later read in a TLD reader. An estimation of radiation exposure to the operating surgeon was made based on average screening exposure time and surgeon’s position.

RESULTS
The mean time of performing PCNL procedure was 116 minutes (range, 42 to 160 minutes). The mean fluoroscopy screening time during the procedure was 4.5 minutes (range, 1 to 8 minutes). Fluoroscopy screening time during the procedure decreased with increasing experience of surgeon, resulting in radiation exposure decrease.

The mean fluoroscopy tube potential was 73 kVp and tube current mean was 2.8 mA. The additional radiation exposure was not monitored.

The estimated scatter exposure rate at 40 cm from the x-ray beam of the operating surgeon for each procedure was: 0.47 µGy to the head, 0.04 µGy to the eye glasses, 0.21 µGy to the fingers, and 4.1 µGy to the legs. The estimated scatter exposure rate at different points from the x-ray beam for the assistant was: 0.05 µGy to the head, 0.01 µGy to the eye glasses, 0.025 µGy to the fingers, and 0.1 µGy to the legs. The estimated scatter exposure rate at all different points from the x-ray beam for circulating nurse was: zero (0).

DISCUSSION
Fluoroscopic imaging is widely practiced in various interventional procedures. Although collimation of the x-ray beam prevents direct radiation exposure to the urologist and assisting personnel, the patient becomes a secondary source of exposure through radiation scatter by absorbing radiation during the procedure. Therefore, it is imperative to measure radiation exposure to patients and the staff to maintain safe levels of cumulative radiation.

The International Commission on Radiation Protection recommends an effective dose of 20 mSv per year over a defined period of 5 years on average as the occupational dose limit. According to our findings, radiation exposure dose to the
operating room staff is less than 1% of permissible annual limits; however, radiation exposure dose to the urologist was greater in comparison to the assistant and the nurse, which is due to his/her closer proximity to the x-ray tube. Our results clearly place the intensive care environment well below the hazardous level of radiation exposure, even in the case of pregnant staff.

In our study, the highest radiation exposure dose was to the legs for the operating surgeon and assistant with 4.1 µGy and 0.1 µGy, respectively. Hellawell and colleagues have shown that the surgeon received the highest radiation exposure with the lower leg (11.6 ± 2.7 µGy) and the foot (6.4 ± 1.8 µGy) receiving more radiation than the eyes (1.9 ± 0.5 µGy) and the hands (2.7 ± 0.7 µGy).\(^6\)

The radiation exposure to the fingers of urologists reported in previous studies are as below: 360 µGy (Kumari), 145 µGy (Bowshar), 340 µGy (Law), 5800 µGy (Rao), and 280 µGy (Kumar), while it was 0.2 µGy in our study. Probably, it is due to advances in technology, the urologist experience, fluoroscopy time, and intensive care from radiation exposure.\(^{10}\)

Rao and associates documented a mean total radiation dose of 5.2 mSv to the hands, 7.5 mSv to the fingers, and 1.6 mSv to the eyes, with the mean fluoroscopy time of 21.9 minutes, which was very high in comparison to that cited in literature.\(^{11}\) In a study by Kumari and coworkers, the mean radiation exposure dose to the patient was 0.56 ± 0.35 mSv, while the mean incident radiation exposure to the finger of the urologist was 0.28 ± 0.13 mSv.\(^{12}\)

CONCLUSION

Our results demonstrated that the operating room staff are within the safe radiation dose limits during PCNL; however, following proper precautions as well as efficient fluoroscopy and avoiding useless exposure during the procedure can further reduce the dose, especially the scattered radiation. Care must be taken by all the staff operating in the field to achieve as low as reasonably achievable dose by adhering to good practices.

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CONFLICT OF INTEREST

None declared.

REFERENCES