Ocular Radiation Exposure in Modern Urological Practice

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Purpose: The human eye is a highly radiosensitive portion of the body and repeat radiation exposure can lead to cataract. The minimum fractionated long-term dose to initiate cataract formation is about 2,500 mSv. We determined whether further radiation related precautions are necessary to protect the eyes of the surgeon.

Materials and Methods: Radiation doses received near the right eye of the operating surgeon were measured with a thermoluminescent dosimeter badge worn near the eye of 6 urologists for a single endourological procedure at an academic center. Procedures included stent insertion, ureteroscopic lithotripsy and percutaneous nephrolithotomy. The mean radiation dose was calculated. Extrapolated doses required to potentiate cataract formation were also calculated.

Results: We assessed 28 urological procedures for radiation exposure, of which 13 were ureteroscopy done for calculus disease (range 0.05 to 0.66 mSv) and 7 were ureteral stent insertion (range 0.13 to 0.32 mSv). The mean radiation dose received during these cases was 0.208 mSv. Based on the mean dose and an average of 20 such cases per month, it would take about 50 years to reach the minimum threshold for progressive cataract formation. Eight percutaneous renal operations were performed and the mean dose received was 0.125 mSv (range 0.04 to 0.22). Based on 10 cases per month, this would require more than 160 years of exposure to reach the minimal threshold.

Conclusions: Long-term radiation can lead to cataract formation. However, the accumulated lifetime exposure of the typical urologist may not necessitate further safety precautions, such as lead-lined glasses.

Key Words: ureter, eye, radiation tolerance, ureteroscopy, stents

Abbreviations and Acronyms

DAP = dose area product

PCNL = percutaneous nephrolithotomy

TLD = thermoluminescent dosimeter

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Many health care providers are subject to radiation exposure throughout the typical work day, including most urologists. Although there is no direct evidence of increased use of radiation emitting technology by urologists, there is a marked global increase in nephrolithiasis.[1] The United States has been a part of this global increase with nephrolithiasis prevalence rates approximately doubling in recent decades.[1–5] The sheer stone burden, and the popularization of ureteroscopy and PCNL as treatment modalities have increased potential radiation exposure to the modern urologist.

Radiation safety awareness and guidelines have evolved since the discovery of x-rays in 1895 by Roentgen.[6] The radiation safety principles specific to urologists that were initially reviewed in the 1980s by Preminger et al[7] have been expanded in recent years.[8] The eye of the surgeon is often a portion of the body that is left unprotected during urological cases, raising

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concern for possible radiation induced damage. Cataract formation is the typical sequelae of radiation exposure to the eye and the radiation doses required to instigate this disease process are well characterized.

We evaluated our experience with radiation doses received near the right eye of the operating surgeon during typical endourological cases. Based on these exposure levels, we determined whether further radiation related precautions are needed to protect the eyes of the surgeon.

MATERIALS AND METHODS

We prospectively maintained a database of surgical cases using a radiation emitting imaging source from March to December 2010. The database included surgeon, surgeon training level, patient demographic data, procedure performed, radiation source, laterality, fluoroscopy duration, and -kVp and mA. For each surgical case the primary surgeon wore a solitary TLD badge above the right eye during a single endourological procedure. All cystoscopic and ureteroscopic procedures were performed using an under couch x-ray tube table and each PCNL was performed using a modern C-arm. The ALARA (as low as reasonably achievable) principle was upheld, including thyroid shields, lead-lined aprons, judicious fluoroscopy use and a maximum operating distance from the radiation source. Notably, throughout the study no surgeon wore lead-lined eye protection.

The TLD badges were then given to a single radiation physicist blinded to all surgical and patient information. The badges were sent for analysis and the data were collected and interpreted by the same radiation physicist. Before data analysis the expected ocular radiation dose was calculated with initial DAP values using radiation estimation based on NCRP (National Council on Radiation Protection and Measurements) report 49 formalism.[9] Dose estimates were also based on intraoperative factors such as kVp and mA when DAP data were not available. The data were retrospectively reviewed and extrapolated based on a set mean number of surgical cases to reach radiation thresholds previously established to incite cataract formation.

RESULTS

We evaluated 28 procedures for radiation exposure to a total of 6 urologists, including 13 ureteroscopic cases (predominantly calculus disease), 7 cystoscopic cases with ureteral stent insertion for hydronephrosis due to intrinsic or extrinsic obstruction and 8 PCNLs (see table and supplementary table at http://jurology.com/). For ureteroscopic cases radiation exposure ranged from 0.05 to 0.66 mSv and for simple cystoscopy with ureteral stent insertion radiation exposure ranged from 0.13 to 0.32 mSv. All calculi were ureteral. Mean calculus size was 0.78 cm and 2 operations involved 2 calculi each. All 18 common endourological cases were performed on an under the table x-ray tube system in patients with a mean weight of 88.8 kg with a mean fluoroscopic time of 3.4 minutes and a mean ± SD ocular radiation exposure of 0.208 ± 0.177 mSv.

Percutaneous nephrolithotomy

Stone Size (mm)	Side	Fluoroscopic Time (mins/secs)	Exposure (mSv)	
			Estimated	Ocular
Unavailable*	Lt	6/14	0.2525	0.07
Less than 20*	Lt	6/23	0.2586	0.08
Less than 20	Lt	10/05	0.4085	0.18
8	Rt	Unavailable	Unavailable	0.22
Less than 20	Lt	Unavailable	Unavailable	0.08
Greater than 25	Rt	4/25	0.1789	0.06
Greater than 20	Lt	17/00	0.6888	0.27
15	Lt	6/37	0.2681	0.04

* PCNL performed for encrusted ureteral stent.

Six of the 8 PCNL cases were performed to treat renal staghorn calculi and 2 were done to extract a retained ureteral stent associated with a large staghorn calculus. The mean overall stone burden was 2.13 cm. Radiation exposure was 0.04 to 0.22 mSv, mean fluoroscopy time was 8.27 minutes, mean ocular dose exposure was 0.125 ± 0.086 mSv and mean patient weight was 93.9 kg. All PCNL cases required initial access and fluoroscopy was used at surgery. Initial access was achieved by the urologist, who was typically less than 48 inches from the patient and C-arm throughout the surgery due to instrumentation limits. The figure shows expected, actual and detrimental radiation levels with time.

DISCUSSION

The ICRP (International Commission on Radiological Protection) has released updated radiation exposure guidelines recommending a whole body radiation dose of less than 50 mSv per year, less than 500 mSv per year to the extremities and less than 150 mSv per year to the eyes.[9] Measures to reduce radiation exposure were also outlined, including minimizing the duration of radiation use, maximizing the distance from the radiation source, proper shielding and optimizing the procedure.[8,9]

Optimization includes several modifiable factors, including equipment. We used an under couch or under the table x-ray tube system and a modern GE OEC 9800 Elite C-arm system (GE Healthcare, Salt Lake City, Utah). Under couch tube systems have lower occupational exposure levels than over couch systems. This decrease is significant enough for the ICRP to recommend their use and suggest that over couch systems could lead to doses potentially significant to unprotected eyes.[9] Modern C-arm systems also provide the capacity to decrease radiation exposure through pulsed fluoroscopy and last image hold