Determination of Patient Radiation Dose During Ureteroscopic Treatment of Urolithiasis Using a Validated Model

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Abbreviations and Acronyms

CT = computerized tomography

ED = effective dose

EDR = ED rate

KUB = x-ray of kidneys, ureters and bladder

MOSFET = metal oxide semiconductor field effect transistor

URS = ureteroscopy

W_T = tissue weighting factor

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Study received institutional review board approval.

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Purpose: We measured organ specific radiation dose rates and determined effective dose rates during simulated ureteroscopy using a validated model. To calculate the effective dose, patients were exposed to ureteroscopic management of stones at our institution.

Materials and Methods: A validated anthropomorphic male phantom was placed on a fluoroscopy table and underwent simulated ureteroscopy. High sensitivity metal oxide semiconductor field effect transistor dosimeters were placed at 20 organ sites in the phantom and used to measure organ specific radiation doses. These dose rates were multiplied by the appropriate tissue weighting factor and summed to calculate effective dose rates. Also, we retrospectively reviewed the charts of patients who underwent ureteroscopy at our institution. A total of 30 nonobese males with data on fluoroscopy time were included in analysis. The median effective dose was determined by multiplying median fluoroscopy time by the effective dose rate.

Results: The skin entrance was exposed to the highest absorbed dose rate, followed by the small intestine (mean ± SD 0.3286 ± 0.0054 and 0.1882 ± 0.0194 mGy per second, respectively). The mean effective dose rate was 0.024 ± 0.0019 mSv per second. Median fluoroscopy time was 46.95 seconds (range 12.9 to 298.8). The median effective dose was 1.13 mSv (range 0.31 to 7.17).

Conclusions: The fluoroscopy used during ureteroscopy contributes to overall radiation exposure in patients with nephrolithiasis. Nonobese males are exposed to a median of 1.13 mSv during ureteroscopy, similar to that of abdominopelvic x-ray. More data are needed to determine clinical implications but urologists must be aware and decrease patient radiation during ureteroscopy.

Key Words: ureter, nephrolithiasis, radiologic health, ureteroscopy, fluoroscopy

FLUOROSCOPY is commonly used during nephrolithiasis treatment. Percutaneous nephrolithotomy, shock wave lithotripsy and ureteroscopy are done under fluoroscopic guidance. Portions of percutaneous nephrolithotomy or shock wave lithotripsy can be performed with ultrasound but URS is exclusively done with fluoroscopy. Radiation from fluoroscopy contributes to the overall radiation exposure of patients with stones. They are also exposed to ionizing radiation from diagnostic imaging, such as CT, KUB, excretory urogram and nuclear medicine scans.

The concern over increased patient radiation exposure is related to the subsequent risk of malignancy. Due to these concerns it is important to

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determine the amount of radiation that patients are exposed to during medical procedures. Fluoroscopy time is often used to report patient radiation exposure during surgical procedures. However, fluoroscopy time alone does not provide information on the actual amount of radiation exposure. Different organs have different radiosensitivity and radiation is not absorbed uniformly.

ED is a derived value that relates the amount of radiation absorbed to the risk of malignancy. We determined organ specific radiation dose rates and calculated EDR during URS using a validated model. We also determined the actual ED received by patients during URS based on our model.

MATERIALS AND METHODS

An anthropomorphic 173 cm tall, 73 kg Model 701-D male phantom (CIRS, Norfolk, Virginia) validated for human organ dosimetry measurements was used to determine organ specific radiation doses (fig. 1, *A*). The phantom is composed of 39 contiguous axial slices, each 25 mm thick. The slices have numbered locations representing the anatomical sites of internal organs (fig. 1, *B*). The locations are optimized for organ dosimetry. High sensitivity Model TN-1002RD MOSFET dosimeters (Best Medical, Ottawa, Ontario, Canada) were used to measure organ dosages. Each detector was calibrated at 80 kVp using the UroView® fluoroscopy unit.

Organ Specific Dose and ED Rate Measurement

The phantom was placed supine on the OEC® UroView 2800 fluoroscopy table and positioned in standard fashion for ureteroscopy. The x-ray emitter for this unit is located above the patient. MOSFET detectors were placed at 20 organ locations in the phantom, including the skin entrance surface, (fig. 1, *C*). The image was collimated to incorporate the region from kidneys to bladder (fig. 2). This has been our practice during ureteroscopy since it allows for visualization of the entire ureteral course.

Fluoroscopy was done in the straight anteroposterior orientation. Three 5-minute continuous runs of fluoroscopy were performed at a setting of 80 kVp and 3.0 mA. These settings were determined by the fluoroscopy unit automatic brightness control and provided an ideal image (fig. 2). The specific absorbed radiation dose in mGy was determined for each organ location during each 5-minute fluoroscopy run. Organ dose rates in mGy per second were calculated by dividing organ doses by fluoroscopy time. Equivalent dose rates in mSv per second were calculated by multiplying organ dose rates by W_T, based on International Commission on Radiological Protection Publication 103.[1] Equivalent dose rates were summed to calculate EDR in mSv per second.

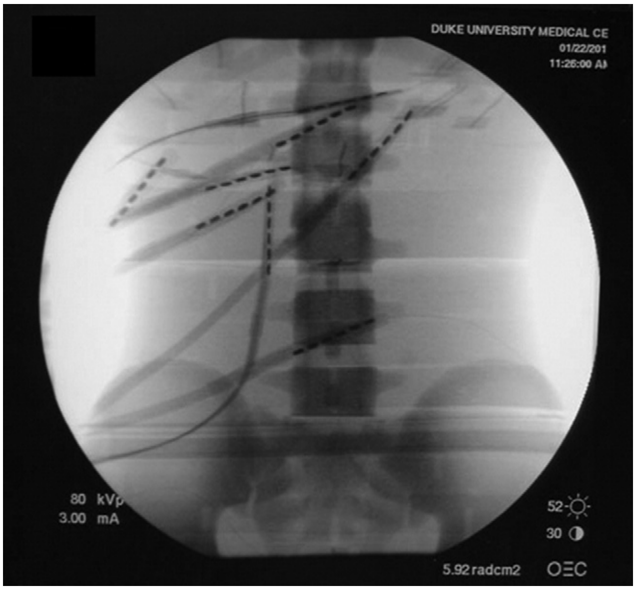

Figure 2. Phantom fluoroscopic image

Actual ED During Ureteroscopy

After obtaining institutional review board approval we retrospectively reviewed all URS procedures for urolithiasis performed by a single surgeon (GMP) at our institution from March 2010 to October 2010. We identified 140 URS procedures done for ureteral and/or renal calculus.

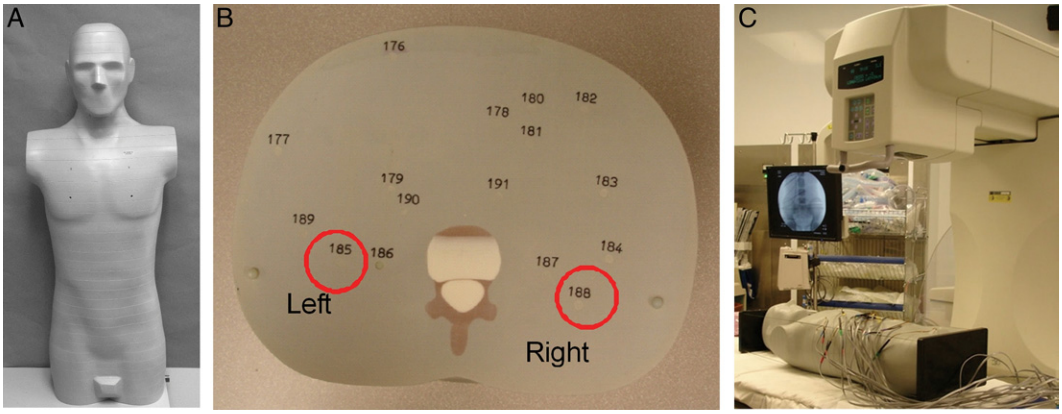

Figure 1. *A*, anthropomorphic male phantom. *B*, representation of axial slice with numbers representing organ sites. *C*, male phantom with μ MOSFET sensors in place.