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Determining Fluoroscopic Radiation Exposure to the Urology Resident

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Abstract

Fluoroscopy has grown to become a critical technology for the modern urologist. The safety of fluoroscopic radiation has been evaluated in a variety of settings however it remains understudied in the urology literature. This study evaluates radiation exposure in the urology fluoroscopic suite. Dosimeter badges were worn by resident and attending urologists to measure radiation exposure during fluoroscopic cases. Exposure was also measured by calculating cumulative air kerma for each case type eg., laser lithotripsy, stent placement. It is estimated that the urology resident and the attending are exposed on average to 3.25 Rem/year and 0.46 Rem/year. Physicians spending above average time in the fluoro suite, i.e., urology residents were not exposed to radiation levels above safety guidelines.

Keywords: Urology; Resident; Radiation; Fluoroscopy; Exposure

Introduction

Recent years have brought renewed and appropriate attention to radiation safety and utilization. Numerous studies have focused on evaluating patient and operator exposure to ionizing radiation, with particular attention aimed at interventional radiology, interventional cardiology, and orthopedics [1-8]. In addition to these groups, a fourth specialty, urology, makes consistent and considerable use of fluoroscopy during minimally invasive endourologic procedures, yet exposure to the urologist as an operator remains a relatively under studied field [9-12].

With increasing pressure from patients to utilize the latest technologies as well as wide systemic focus on minimally invasive treatments, fluoroscopically aided urologic procedures comprise an ever increasing portion of urologic surgery [13]. To date, the few studies which have specifically evaluated urologists have reassuringly determined that annual exposure rates are likely inconsequentially low, perhaps as low as 2% of NCRP/ICRP (National Council on Radiation Protection/International Council on Radiation Protection) maximum tolerances [12]. It should be noted, however, that when determining these levels of exposure, researchers have elected to use general urologists as their study subjects. In 2012, in the United States, the average age of a practicing urologist is 52.5 years, with 18% of urologists being greater than 65 years old [14]. Additionally, studies have thus far focused on general community urologists and their average case loads, assumptions that may drastically underestimate the typical case distribution and volumes encountered at academic institutions [13].

Worth adding to the discussion is the realization that numerous studies have demonstrated an age dependent risk association with radiation exposure, where younger age at the time of exposure corresponds to higher risk [15]. This observation immediately raises two points: 1. General urologists throughout the community, due to their increased average age, are likely at somewhat decreased risk from occupational radiation exposure, and 2. The youngest subset of urologists, presumably training resident physicians, may be at the greatest risk. Additionally, while in training, it is common for residents to operate with a series of attending urologists, thus encompassing a far greater, and possibly more diverse, annual case load than the majority of post-training general urologists. Knowledge of these factors has led to a hypothesis that previous studies may have significantly underestimated the degree of radiation exposure to urologists in residency training. This research aims to estimate annual radiation exposure from intraoperative use of fluoroscopy for this unique and high risk subset of urologists.

Methods

A total of 220 consecutive cases performed in the end urology suite of 3 participating facilities (Sibley Memorial Hospital (SMH), Medstar Georgetown University Hospital (GUH), and Medstar Washington Hospital Center (WHC), were evaluated in regard to utilization of fluoroscopy. Cases were performed over a 60 day period with all data collected and recorded immediately post-procedure. No subject identifiers were recorded to insure HIPAA compliance. With the exception of the primary investigator and the contributing resident physician researchers, all other physicians were informally blinded and not informed of any evaluation of fluoroscopy utilization during their cases.

Recorded case types included primary ureteral double-J stent placement, ureteral double-J stent exchange, and uretero-renoscopy with/without laser lithotripsy and double-J ureteral stent placement. Other fluoroscopic procedures, including fluoroscopic cystograms and retrograde pyelograms without ureteral stenting/ureteroscopy were excluded from data collection due to their rarity at participating institutions and inability to estimate annual number of these case types based on resident physician ACGME case logs. Additionally, percutaneous nephrolithotomy cases were excluded from data collection it is the current practice pattern at the participating institutions to have interventional radiology obtain the percutaneous access. The urology team remains outside of the operative suite while fluoroscopy is used for all PCNL cases. Participating institutions perform a relatively limited amount of extracorporeal shock wave lithotripsy (ESWL), and no procedures were performed at any participating institutions during the data collection period therefore all PCNL and ESWL cases were excluded from this analysis.

Data collected for each procedure included; type of procedure; laterality; total procedure length; total "fluoro on" time; utilization of Mag function; and Kerma Area Product (KAP) determined by the internal fluoroscopic table sensor. Varying fluoroscopy table types/ manufacturers are utilized by the different participating institutions; SMH: Liebel-Flarsheim®, MGUH: GE®, WHC: Liebel-Flarsheim®.

Radiation exposure of the surgeon was measured in two ways. The first, by direct measurement through optically stimulated luminescent dosimeters (Luxel®) worn by participating physicians on the outside collar of the lead apron. The second, by estimating cumulative air kerma using the inverse square law as applied in previous studies [16-18]. Distance from radiation source to the patient was measured to be on average 38 cm. Mean distance perpendicular to the vertical axis of the radiation beam to the chest of the primary operator was calculated to be 60 cm. Utilizing previously established scatter and decay estimations, the dose at 1 m perpendicular from the radiation beam is approximately 1/1000th dose, it is estimated that 0.27% of the emitted dose will be experienced by the operator. Multiplying the gross annual cumulative air kerma by the calculated decay rate yielded our estimated annual exposure. This was initially calculated using mGy and subsequently converted to Rem for uniformity of units [16-18]. Monthly averages were computed and returned by Luxol®. These exposure levels were multiplied by 12 to estimate annual exposure.

At the conclusion of the 60 day period of data collection, the mean cumulative air kerma for each case type was calculated by reviewing dosimeter readings for each case and by estimating cumulative air kerma through the inverse square law as described above. ACGME case logs were reviewed for all residents completing a minimum of 2 years of urologic training between 2006 and 2011 at Medstar Georgetown University Hospital/Washington Hospital Center. Additionally, these same physicians were polled to determine the mean age at the initiation of urologic surgery training. After determining the average annual volume for each particular case type, the per case average cumulative air kerma was multiplied by the average number of each case type performed in a year. This yielded a gross annual cumulative air kerma.

Results

During the 60 day period, 220 procedures utilizing fluoroscopy were completed at the participating institutions. These were divided into 3 fundamental case types: ureteroscopy +/- laser lithotripsy +/- ureteral stenting (N=154), primary ureteral double-J stent placement (N=27), and ureteral double-J stent exchange (N=39). The average fluoroscopy time for each procedure was: ureteroscopy (2.47 min), primary stent placement (2.41 min), and stent exchange (0.99 min). Considering all cases during the study period, the per case average fluoroscopy use was 42.8 mGy/cm^2/case. The MAG function of the fluoroscopy units was utilized in 6 of the 220 cases (1.48%) and this subset of cases averaged 84.93 mGy/cm^2 (range 33.6-176.5 mGy).

Kerma air product for each procedure as recorded by the KAP sensor on each fluoroscopy machine was: ureteroscopy (47.44 mGy/cm^2, range 1.3-152.91 mGy/cm^2), primary stent (53.55 mGy/cm^2, range 4-176.48 mGy/cm^2), stent exchange (16.59 mGy/cm^2, range 2-94 mGy/cm^2). Predicted percentage of radiation incident upon the operator at chest level (90°) a distance of 60 cm from the radiation source is calculated to be 0.27% of the gross cumulative air kerma. Utilization of ACGME case logs reveals annual caseloads for these years to be: ureteroscopy (113.5), primary stent (37), and stent exchange (52.5) per resident. The mean annual radiation exposure to the resident was calculated by multiplying the average case load by the estimated radiation exposure per case, 2.29 Rem/year. Kerma area product sensors have been previously determined to estimate true emitted radiation with +/-2% variability; however, estimated variability due to patient factors (body habitus, etc) may account for +/- 30% variability. Accounting for this, range of exposure is estimated to be 1.61-2.99 Rem/year.

Optically stimulated luminescent dosimeters (Luxol®) worn on the outside of the surgeon's lead served as controls and verification modalities. Resident and attending exposure were found to average 270.5 mRem/month and 38.5 mRem/month respectively. This extrapolates to an annual exposure of 3.24 Rem/year for the resident and 0.46 Rem/year for the attending physician.

Regulation conforming lead aprons and thyroid shields were worn at all times by operators and all personnel within the fluoroscopy suite. Assuming an approximate 100 fold decrease in radiation exposure secondary to shielding [12], exposure to the thyroid, chest, abdomen and gonads can be estimated to be 0.023 Rem/year. Current NCRP/ ICRP guidelines stress a maximum annual work related radiation exposure of 5Rem/year (50 mSv/year). Including accepted variability and inaccuracy of sensors/calculations, this study estimates annual exposure to resident urologists in this program to be 45.8% (range 32.1%-59.5%) of NCRP/ICRP maximums [19].

Discussion

The results of this study suggest a considerable, but tolerable, level of ionizing radiation exposure to resident physicians training in fluoroscopic guided endourology. Consistent with previous studies which have similarly found urologists to be exposed to a low percentage of the NCRP/ICRP maximum allowable annual radiation dose, this study concludes that even a high risk subset of urologists, resident physicians (relatively younger age and higher case load), are not exposed to levels of radiation in excess of accepted annual maximums. Despite being within an acceptable range, the exposure level for resident physicians does still appear to far exceed exposure levels for practicing general urologists, perhaps by as much as 20-25 fold. Of note, however, if this level of exposure were to persist for 5 years, this degree of exposure may in fact exceed ICRP (but not NCRP) cumulative maximums (cumulative dose of 10 Rem over any 5 year time period) [19].

Beyond identifying yet another peril of urologic residency, the authors believe this data, given changing practice patterns and increased utilization of ureteroscopy, may offer further insight into expected levels of radiation exposure to all urologists. Our increased series size, and particularly the large number of ureteroscopic procedures, may offer a rough estimate of per case exposure that can be extrapolated to general urologists. The authors find the results of this study cautiously reassuring for the urology community as a whole, as we suspect the vast majority of urologists have case loads and subsequent exposure levels significantly below those estimated by this evaluation.

When interpreting these findings, however, the authors must concede numerous limitations. Utilizing the cumulative air kerma as a surrogate for emitted radiation and subsequently extrapolating it to radiation incident upon the surgeon likely inserts a significant amount of error, perhaps as much as +/-30%. It has been well documented that radiation scatter and decay are very dependent upon the shape, density, and tissue type upon which they are incident, all factors that are unaccounted for in this study [16]. Given the profound variations in patient body habitus, financial limitations of this study, and our desire for a large sample size, there is no accurate or practical way to directly measure radiation exposure to the surgeon on an individual case-by-case basis. As an alternative, we have relied upon mathematical formulas and patterns derived and identified by previous studies, undoubtedly adding some additional degree of error. Ideally, this study would have been completed by placing real time, highly accurate dosimeters at various locations (head, collar, hands, and feet) on the surgeon with exposure data collected in detail for each case within the series. This in turn would potentially reveal a more accurate determination of exposure levels. Financial restrictions, however, precluded this, and particularly given the large series size, eliminated the possibility of having radiation safety monitoring personnel present for all cases.

Despite these limitations, the investigators believe that the findings of this study are still valuable. Undoubtedly, increased case load and utilization of fluoroscopy will increase occupational exposure to ionizing radiation. Furthermore, the association between age at the time of exposure and concurrent increased risk of detrimental effects must remain in the consciousness of all urologists and physicians utilizing fluoroscopy, particularly resident physicians and their academic instructors. Although exposure levels are estimated to be within an acceptable range, there is still clearly room for improvement.

It is the opinion of the authors that urologists in general can only benefit from increased education about radiation safety and monitoring. Our case series illustrates the dramatic increase in radiation exposure with use of the MAG feature as well as the tremendous variability in amount of fluoroscopy use from case to case. Judicious use of fluoroscopy in general, and with features such as MAG, can significantly reduce the operator exposure. The principle of ALARA (using "as low as reasonably acceptable" amounts of radiation) should remain a priority for all cases utilizing fluoroscopy. Additionally, the vital importance of adequate shielding cannot be overstated. Too often, in the investigator's experience, resident physicians are forced to utilize older lead, often shared between numerous services. Given the degree of exposure and the vulnerable age at which these exposures occur, the adequacy of this lead should be confirmed and strictly monitored. Radiation exposure to resident physicians training in high volume endourology centers may not exceed the NCRP/ICRP maximum annual tolerances, however, they remain considerable, particularly in the context of younger age and numerous, sustained years of moderate/high exposure. We stress the importance of continued safety monitoring and education for all physicians utilizing intraoperative fluoroscopy, particularly urologists.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was not obtained from all individual participants (physicians) included in the study to preserve the blinded study design. This research project was approved by all IRBs of participating institutions.

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