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Radiation Exposure in Dialysis Access-Related Procedures Decreases with Increase in Number of Procedures Performed by the Interventional Nephrologist

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ABSTRACT

An appreciation of the inherent risks with radiation exposure to patients and to the physician performing the procedure and the staff is urgently needed. The objective of this study is to assess radiation exposure to both patients and interventional nephrologists performing procedures and see any trends in the procedure and fluoroscopy times over a 2-year period. A total of 400 procedures performed at our vascular access center by a new to practice interventional nephrologist were recorded and retrospectively analyzed. Fluoroscopic time and procedure time for various procedures over the course of 2 years were recorded. This data were subsequently separated into eight groups (four quarters per year) based on the date of the procedure. Our study demonstrates a decrease in mean and median fluoroscopy times and procedure times for newly trained interventional with gain in number of procedures. The mean fluoroscopy time for the first two quarters was 5 minutes and 4 seconds, and the median was 3 minutes and 37 seconds. The mean procedure time for the first two quarters was 38 minutes, and the median was 32 minutes. The mean fluoroscopy time for the last two quarters was 1 minute and 54 seconds, and the median was 1 minute and 26 seconds. The mean procedure time for the last two quarters was 27 minutes, and the median was 21 minutes. In conclusion, gain of experience by the practicing Interventional Nephrologist from performing an increasing number of procedures leads to decreased procedure times and fluoroscopy times, which lowers the risk of radiation.

In the United States, the average effective radiation exposure from background environmental sources is estimated to be < 3 mSv per year (1). There is a growing concern on the effects of ionizing radiation from medical imaging procedures (2). Hemodialysis patients have substantial exposure to ionizing radiation (3). In the United States, there has been a rise in the number of dialysis access-related interventions and vascular centers over the last few years, which has increased the potential for both patients and physicians performing procedures to be exposed to significant amounts of ionizing radiation (4). With the exception of California and a few other states, there is no requirement to pass an examination to obtain the fluoroscopy supervisor and operator permit to operate the X-ray/fluoroscopy machine to perform procedures in an outpatient vascular access center (5). Therefore, a rigorous understanding of the core curriculum of principles and practice of radiation safety is neither uniform nor universal among interventional nephrologists. Inherent risks include unnecessary radiation exposure to both patients and the facility staff participating in the procedure.

The two primary sources of radiation encountered in these settings are (i) diagnostic equipment such as mobile C-Arm fluoroscopy machines, traditional attached fluoroscopic machines and portable X-ray machines; and (ii) radio nuclides used in diagnosis and treatments such as gamma cameras, radioactive isotopes and bone scans (5). Although interventional nephrologists receive significantly less exposure to radiation than interventional cardiologists and interventional radiologists, they receive a considerable amount of radiation (Table 1).

The aims of this study are (i) to test the hypothesis that a greater number of procedures performed by an interventional nephrologist will result in a decrease in both procedure time and fluoroscopy time and (ii) to assess radiation exposure to both patients and interventional nephrologists performing procedures over a 2-year period.

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TABLE 1. Average annual dose according to occupational category

Occupational category	Average annual dose (mrem[a])
Uranium miners	2300
Radiology special procedures	1800
Interventional cardiology	1600
Nuclear power operators	550
Interventional nephrologists at lifeline	375[b]
Radiotherapy	260

Adapted from National Council on Radiation protection and measurements (NCRP) http://www.ncrppublications.org.

[a]mrem stands for milliRöntgen equivalent in man; 1 rem = 0.01 Sv = 10 mSv = 10,000 μSv; 1 millirem = 0.00001 Sv = 0.01 mSv = 10 μSv.

[b]Exposure data provided by Life Line Vascular Access Center Company where 98% of staff have annual exposure ≤375 mrem.

Methods

After the approval of the Institutional review board, procedure time and fluoroscopy time of all procedures performed at our outpatient access suite were entered in the database from July 1, 2008 to July 6, 2010 and were retrospectively analyzed and compared to national standards. Type of procedure, complications, and demographic data were also analyzed. In the calculation of fluoroscopy time, procedures that did not use fluoroscopy were excluded from the final analyses. The procedure time and fluoroscopy time were compared between all the quarters from the inauguration of the practice to the most recent quarter. The angioplasty and thrombectomy times were also compared between the first quarter (July–September 2008) and the last quarter (April–June 2010). A literature search for radiation safety and exposure during procedures performed by interventional nephrologists was reviewed.

Results

A total of 400 procedures were performed in eight quarters. Fluoroscopy was used in 300 procedures. Of these, 23 were catheter-related procedures that required fluoroscopy. The mean fluoroscopy time for the first two quarters was 5 minutes and 4 seconds, and the median was 3 minutes and 37 seconds. The mean procedure time for the first two quarters was 38 minutes, and the median was 32 minutes. The mean fluoroscopy time for the last two quarters was 1 minute and 54 seconds, and the median was 1 minute and 26 seconds. The mean procedure time for the last two quarters was 27 minutes, and the median was 21 minutes. The mean and median fluoroscopy times for angioplasty in the first two quarters were 6 minutes and 19 seconds and 5 minutes and 6 seconds, respectively. The mean and median fluoroscopy times for angioplasty in the last two quarters were 1 minute and 51 seconds and 1 minute and 36 seconds, respectively. The mean and median procedure times for angioplasty in the first two quarters were 39 minutes and 38 minutes, respectively. The mean and median procedure times for angioplasty in the last two quarters were 24 and 22 minutes, respectively. The mean and median fluoroscopy times for thrombectomy were 8 minutes and 10 seconds and 7 minutes and 6 seconds, respectively. The mean and median procedure times for fluoroscopy were 1 hour and 18 minutes and 1 hour and 21 minutes, respectively. Over the course of these 2 years, the practicing interventional nephrologist received a deep-dose equivalent (DDE, or external body exposure at a tissue depth of 1 cm) of 47 mrem, an LDE (eye dose equivalent, or external exposure of the lens at a tissue depth of 0.3 cm) of 32 mrem, and an shallow dose equivalent (SDE, or external exposure of the skin or extremity at a tissue depth of 0.007 cm) of 47 mrem.

Discussion

We report here that there is a significant decrease in mean and median fluoroscopy and procedure times with an increased number of procedures performed. There was a progressively decreasing trend toward shorter fluoroscopy and procedure times from the first quarter to the last quarter of the study (Figs. 1, 2, 3, and 4). There was a statistically significant difference in fluoroscopy and procedure time between the first and the last quarters of the study (Figs. 5 and 6). The DDE, LDE, and SDE of the practicing interventional nephrologist over the 2-year period of this study were well below the

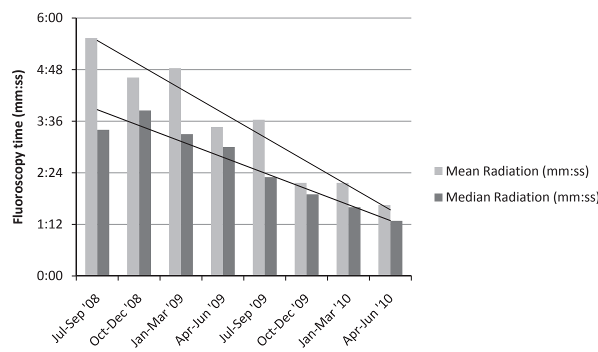

FIG. 1. Mean and median fluoroscopy time.

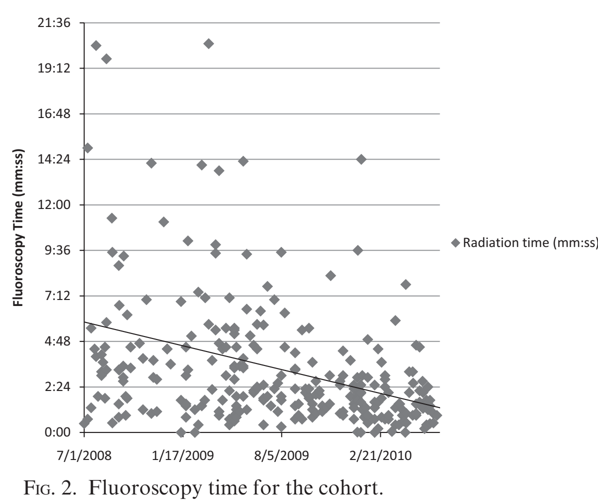

FIG. 2. Fluoroscopy time for the cohort.

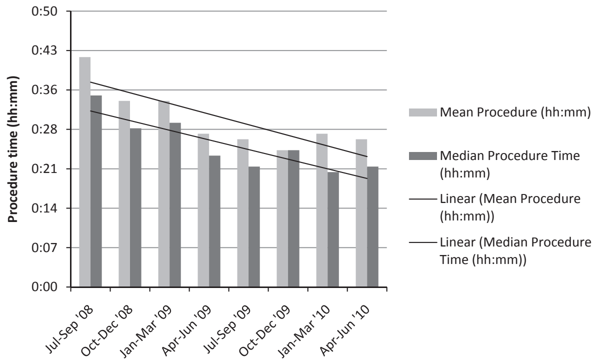

FIG. 3. Mean and median procedure time.

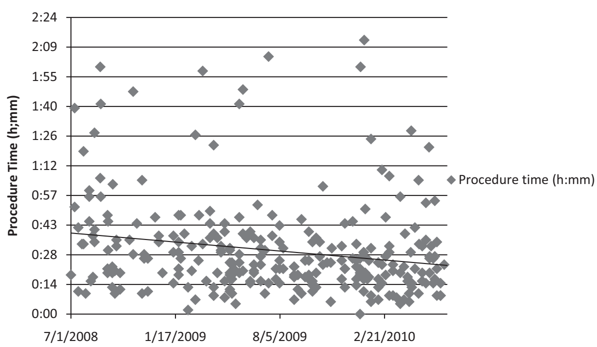

FIG. 4. Procedure time for the cohort.

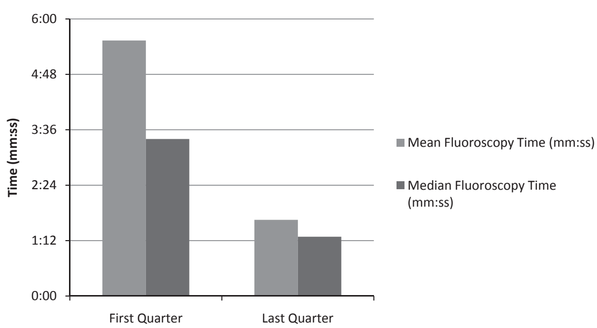

FIG. 5. Mean and median fluoroscopy time in the first and last quarters of the study.

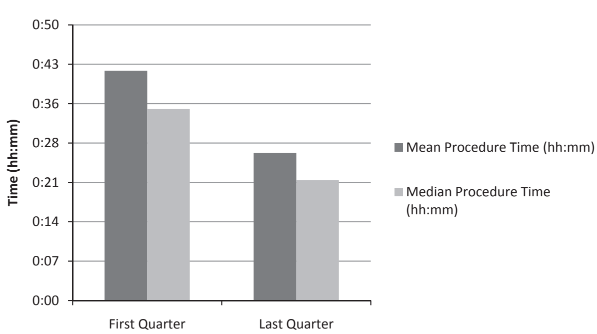

FIG. 6. Mean and median procedure time in the first and last quarters of the study.

limits placed by the United States Nuclear Regulatory Commission (USNRC) (Table 2).

The strengths of this study were that a single facility was used and a single interventional nephrologist performed all the procedures, which removes multiple variables and all procedures which required exposure to radiation were included. One limitation to this study was the limited number of thrombectomy procedures, which did not permit for retrospective analysis of fluoroscopy and procedure times between multiple quarters. As a result, it was not statistically reasonable to retrospectively analyze the similarities and differences in the procedure and fluoroscopy times between the different types of procedures.

TABLE 2. Annual radiation exposure limits

Whole body, blood forming organs, gonads	5000 mrem[a]/year
Lens of eye	15,000 mrem/year
Extremities and skin	50,000 mrem/year
Fetal	500 mrem/gestation period
General public	100 mrem/year

Based on United States Nuclear Regulatory Commission (USNRC) Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain states and other regulatory agencies may adhere to different limits.

[a]mrem stands for milliRöntgen equivalent in man; 1 rem = 0.01 Sv = 10 mSv = 10,000 μSv; 1 millirem = 0.00001 Sv = 0.01 mSv = 10 μSv.

In a previous study reported in 2004, the mean fluoroscopy time for angioplasties was 6 ± 4.8 minutes and the median fluoroscopy time was 4.6 minutes (6). The mean procedure time for angioplasties was 38.8 ± 23.9 minutes, and the median procedure time was 33 minutes. The mean fluoroscopy time for thrombectomies was 8.8 ± 6.4 minutes, and the median fluoroscopy time was 6.9 minutes. The mean procedure time for thrombectomies was 51.8 ± 27.6 minutes, and the median procedure time was 45 minutes. The procedure times of thrombectomies by various percutaneous techniques range from 33 minutes to 3.5 hours (7–12).

Because the fluoroscopic X-ray beam is highly directional, scatter radiation is the main potential hazard to the performing staff and others in the room, making it less difficult to avoid exposure. By simply increasing the distance from the radiation source, one can reduce the radiation exposure by the square of the distance.

Some commonly used methods for nonoperating staff to avoid exposure include remaining at least six feet away or around a corner from the X-ray source, using leaded screens, drapes, and wearing lightweight alloy or leaded aprons, eyeglasses, gloves, hats, etc. Additional measures to reduce radiation exposure include using attenuated dose radiation and pulsed fluoroscopy when possible, keeping the procedure room dimly lit to enhance visibility of the fluoroscopic image, positioning the image intensifier close to the patient, avoiding the use of magnification and other high-dose fluoroscopic exposures when possible, collimation, last image hold, and using a laser or other sight guide for proper patient and positioning of the C-arm. Patients and staff who are pregnant should not be exposed to radiation. Patients may be given the option to wear lead aprons, and lead drapes should be present in areas not directly in the beam path. Also, we propose that patients with chronic kidney disease/end-stage renal disease (CKD/ESRD) be educated in regard to limits of radiation exposure and maintain an active exposure record.

Chronic kidney disease/end-stage renal disease patients receive more diagnostic and treatment-related imaging including cardiac interventions, peripheral arterial interventions, and cerebra-vascular interventions than the age-matched control population. ESRD patient requires an average of two vascular access-related procedures per year. Patients receiving maintenance hemodialysis regularly have an increased incidence of cancer (13,14).

Fluoroscopic radiation exposure during interventional nephrology procedures includes tunneled dialysis catheter placements and exchange (TDC), angioplasty and thrombolysis of native fistulas, and synthetic grafts. Furthermore, newer techniques for peritoneal dialysis catheters, kidney biopsies, and vessel mapping for dialysis access creation may expose patients and staff to radiation sources as well.

An effort should be made toward establishing standards for radiation safety and explore exposure limits when formulating care for CKD/ESRD patients. We propose that both staff and patients receive formal instruction in radiation safety and maintain an active exposure count.

In conclusion, we show that mean and median fluoroscopy and procedure times decrease with increased number of procedures and experience gained by the interventional nephrologist. Interventional nephrologists can perform these procedures safely and should strive to decrease the radiation exposure to patients and staff.

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