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

Permalink
https://escholarship.org/uc/item/11c8482f

Journal
Seminars in Dialysis, 23(6)

ISSN
0894-0959

Authors
Dukkipati, Ramanath
Tammewar, Gautam
Kalantar-Zadeh, Kamyar
et al.

Publication Date
2010-11-01

DOI
10.1111/j.1525-139x.2010.00798.x

Copyright Information
This work is made available under the terms of a Creative Commons Attribution License, available at https://creativecommons.org/licenses/by/4.0/

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

Ramanath Dukkipati,* Gautam Tammewar,* Kamyar Kalantar-Zadeh,* and Rajiv Dhamija†

*Los Angeles Biomedical Research Institute at Harbor-UCLA Medical Center and the David Geffen School of Medicine at UCLA, Torrance and Los Angeles, California, and †Rancho Los Amigos National Rehabilitation Center, Downey, California

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.
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 procedure times for angioplasty in the first two quarters were 1 minute and 51 seconds and 1 minute and 36 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 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

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

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

---

**TABLE 1. Average annual dose according to occupational category**

---

**FIG. 1.** Mean and median fluoroscopy time.

**FIG. 2.** Fluoroscopy time for the cohort.
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.

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)

| TABLE 2. Annual radiation exposure limits |
|------------------------------------------|
| Whole body, blood forming organs, gonads | 5000 mrem*/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.

*mrem stands for milliRöntgen equivalent in man; 1 rem = 0.01 \( \text{Sv} = 10 \text{ mSv} = 10,000 \mu\text{Sv} \); 1 millirem = 0.00001 \( \text{Sv} = 0.01 \text{ mSv} = 10 \mu\text{Sv} \).
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 cerebro-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.

References

1. Brenner DJ, Doll R, Goodhead DT, Hall EI, Land CE, Little JB, Lubin JH, Preston DL, Preston RJ, Puskin JS, Ron E, Sachs RK, Samet JM, Setlow RB, Zaider M; Cancer risks attributable to low doses of ionizing radiation: assessing what we really know. Proc Natl Acad Sci U S A 100:13761–13766, 2003
2. Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, Shah ND, Nasir K, Einstein AJ, Nallamothu BK: Exposure to low-dose ionizing radiation from medical imaging procedures. N Engl J Med 361:849–857, 2009
3. Kinsella SM, Coyle JP, Long EB, Mc-Williams SR, Maher MM, Clarkson MR, Eustace JA: Maintenance hemodialysis patients have high cumulative radiation exposure. Kidney Int 76:789–793, 2010
4. U.S. Renal Data System UADR: Atlas of chronic kidney disease and end stage renal disease in the United States. 2009.
5. http://www.cdph.ca.gov: Syllabus on radiography and radiation protection. 2010.
6. Beathard GA, Litchfield T; Effectiveness and safety of dialysis vascular access procedures performed by interventional nephrologists. Kidney Int 66:1622–1632, 2004
7. Beathard GA, Welch BR, Maidment HJ; Mechanical thrombolysis for the treatment of thrombosed hemodialysis access grafts. Radiology 206:711–716, 1996
8. Gray RJ; Percutaneous intervention for permanent hemodialysis access: a review. J Vasc Interv Radiol 8:313–327, 1997
9. Trerotola SO, Vesely TM, Lund GB, Soulen MC, Ehman KO, Cardella JF; Treatment of thrombosed hemodialysis access grafts: Arrow-Trerotola percutaneous thrombolytic device versus pulse-spray thrombolysis. Arrow-Trerotola Percutaneous Thrombolytic Device Clinical Trial. Radiology 206:403–414, 1998
10. Rocek M, Peregrihn JH, Lasovickova J, Krajckova D, Slavijokova M; Mechanical thrombolysis of thrombosed hemodialysis native fistulas with use of the Arrow-Trerotola Percutaneous Thrombolytic Device: Our preliminary experience. J Vasc Interv Radiol 11:1153–1158, 2000
11. Vogel PM, Bansal V, Marshall MW; Thrombosed hemodialysis grafts: lysis and wait with tissue plasminogen activator or urokinase compared to mechanical thrombolysis with the Arrow-Trerotola Percutaneous Thrombolytic Device. J Vasc Interv Radiol 12:1157–1165, 2001
12. Middlebrook MR, Amygdalos MA, Soulen MC, Haskal ZJ, Shlansky-Goldberg RD, Cope C, Pentecost MJ; Thrombosed hemodialysis grafts: percutaneous mechanical balloon declotting versus thrombolysis. Radiology 196:73–77, 1995
13. Vadjic CM, McDonald SP, McCreidle MR, van Leeuwen MT, Stewart JH, Law M, Chapman JR, Webster AC, Kaldor JM, Grulich AE; Cancer incidence before and after kidney transplantation. JAMA 296:2823–2831, 2006
14. Stewart JH, Vadjic CM, van Leeuwen MT, Amin J, Webster AC, Chapman JR, McDonald SP, Grulich AE, McCredie MR; The pattern of excess cancer in dialysis and transplantation. Nephrol Dial Transplant 24:3225–3231, 2009