Catheterization and Cardiovascular Diagnosis 21:195–197 (1990)

Preliminary Reports . . . works in progress

Reduction in Radiation Exposure During Coronary Angiography

Margot L. Carpenter, BSRT, Peggy R. Singer, RT, Avanindra Jain, MD, and Gregory J. Dehmer, MD

In addition to lead shielding, increased distance between the operator and x-ray source will lower radiation exposure. To utilize this principle, we interposed a 24 in. piece of pressure tubing between the catheter used for coronary angiography and the manifold apparatus. Radiation exposure to the hand of the operator during coronary angiography was compared with and without the extension tubing. When corrected for the differences in exposure time, operator exposure was 5.38 mrem/min without the extension and 4.84 mrem/min with the extension. Although this is a small difference in exposure/min, a substantial reduction in exposure could accumulate over a 1 yr period. Insertion of this extension tube into the catheter system is a simple and safe way to further reduce operator exposure during coronary angiography.

Key words: cardiac catheterization, radiation protection, lead shielding

INTRODUCTION

Several studies have documented the amount of radiation exposure to medical personnel during diagnostic cardiac catheterization and interventional procedures [1–5]. During diagnostic procedures, the majority of operator exposure occurs during cineangiography and is derived from scattered radiation around the angiography table. Compared with fluoroscopy, the radiation dose during cineangiography is roughly 10-fold higher [5]. Radiation exposure may be decreased by limiting the duration of exposure, maximizing the use of external shielding, and increasing the distance of personnel from the x-ray source. Using the latter of these principles, we report a practical and effective method to further lower operator exposure during coronary angiography.

MATERIALS AND METHODS

X-ray exposure during coronary angiography was measured during a 1 mo period in which no adjustments in x-ray output (μR/cineframe) were made. All procedures were performed by the femoral approach and were randomly allocated to 1 of 2 different methods to connect the coronary catheter to the pressure manifold. With method A, the coronary catheter was connected directly to the pressure manifold; with method B, a 24 in. piece of clear plastic pressure tubing with rotator device was interposed between the catheter and manifold (Fig. 1). Coronary angiography was performed by 2 operators. Operator 1 manipulated the catheter into the coronary artery ostium while operator 2 monitored the arterial pressure and injected small amounts of contrast agent to assist in catheter placement. During manipulation of the catheter into the coronary artery using fluoroscopy, operator 1 was in close proximity to the x-ray tube. Catheter manipulations with the extension tubing were accomplished easily due to the rotator device. After the catheter was engaged satisfactorily into the coronary artery, operator 1 stepped back from the x-ray source and stood behind operator 2. Therefore with the extension tubing (method B), operator 2 could stand approximately 2 ft farther from the x-ray source compared with Method A.

Radiation exposure to an unprotected area of operator 2 was compared for the 2 different methods by using a ring-mounted lithium fluoride thermoluminescent dosimetry chip. This was placed on the 4th finger of the left hand of operator 2 before insertion of the 1st catheter for coronary arteriography. In all cases, the left hand of operator 2 was closest to the x-ray source. The ring dosimetry chip was removed after completion of the last coronary cineangiogram and stored in a lead container between procedures. Standard radiation protection measures used on all procedures included lead aprons covering both the front and back of the operator, thyroid collars, lead glasses with side shields, and a ceiling-mounted radiation screen that was interposed between the patient and operator.

Radiation exposures were monitored independently for each method. After completion of the study period, cumulative radiation exposure to the chips was determined by using standard techniques (Siemens Gammasonics, Inc., Health Physics Services, Des Plaines, IL). Variables were recorded during each procedure which allowed calculation of the exposure rate to the ring dosimetry chip for each method. All cineangiograms were performed at 30 frames/sec by using a 7 in. image-intensifier field size. Although individual projections were adjusted for the

From the C.V. Richardson Cardiac Catheterization Laboratory, University of North Carolina Hospitals, Chapel Hill, NC.

Received February 9, 1990; revision accepted July 9, 1990.

Address reprint requests to Gregory J. Dehmer, M.D., Director, C.V. Richardson Cardiac Catheterization Laboratory, The University of North Carolina Hospitals, 101 Manning Drive, Chapel Hill, NC 27514.

TABLE I. Procedure Variables and X-Ray Exposure Rates

	Method		
	A		B
Patients(n)	16		18
Average exposure time/patient procedure (min)[a]	10.5 ± 7.4	NS	11.8 ± 8.2
Total coronary angiograms performed (n)	164		176
Coronary angiograms performed/patient study (n)	10.2 ± 3.0	NS	9.8 ± 3.0
Average time of exposure/coronary angiogram (sec)[b]	6.80		6.96
Average cineangiography exposure time/patient (sec) [angiograms per patient (n) × ave. time of exposure/angiogram]	69.7 ± 20.4	NS	68.1 ± 21.0
Total exposure time of coronary cineangiography for all case (min) [total angiograms (n) × time per angiogram]	18.59		20.65
Exposure rate (mrem/min) [chip reading (mrems) ÷ total exposure time (min)]	5.38		4.84

[a]Includes all fluoroscopy and cineangiography exposure from the beginning to the end of the entire catheterization procedure.
[b]Determined from a random sample of 30 individual coronary angiograms performed by each method.

optimum visualization of the anatomy in a patient, the same series of views were used in both groups. Generally, this consisted of 4 right anterior oblique and 3 left anterior oblique images of the left coronary system with varying degrees of cranial and caudal angulation and 2 or 3 views of the right coronary artery in right and left anterior oblique projections. Differences between groups were compared with a Student's t-test; $P < 0.05$ was considered significant.

RESULTS

Total exposure to the dosimetry chip worn during method A and method B was identical, 100 mrem for each chip during the study period, but was accumulated over a greater number of patients with method B. The exposure rate was derived by correcting the total exposure by the estimated time of exposure to the dosimetry chip. When the total exposure was corrected for the difference in exposure time, method B had a lower exposure rate to the dosimetry chip during the study period (Table I). The exposure rate for method B was 4.84 mrem/min compared with 5.38 mrem/min for method A. Although this difference may seem small, the cumulative effects over a 1 yr period could be considerable as demonstrated in Table II.

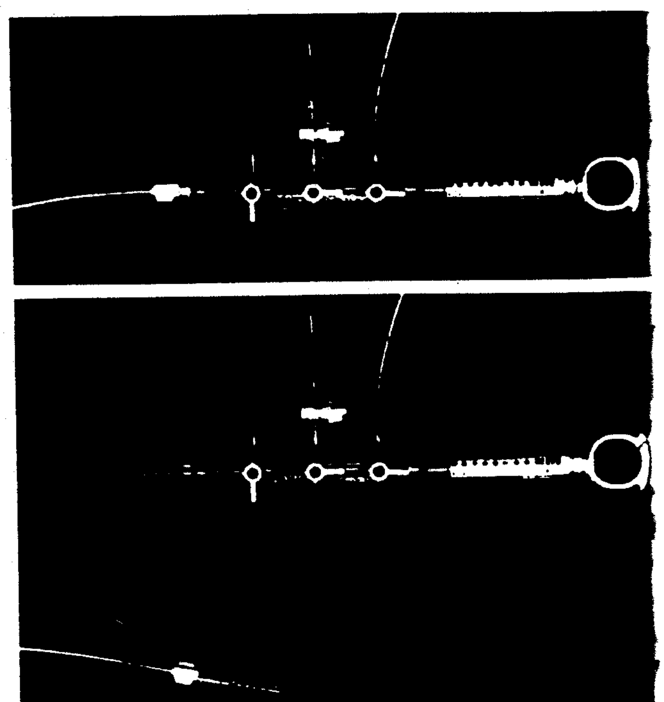

Fig. 1. Catheter connection to pressure manifold used for method A (top) and for method B (bottom.) With method B, a 2 in. pressure tubing and separate rotator device are interposed between the coronary catheter and pressure manifold. When fully extended, the operator can stand a greater distance from the source.

DISCUSSION

The use of protective lead apparel, lead-impregnated glasses, and external radiation shields are strongly rec-

TABLE II: Potential Long-Term Reduction in Radiation Exposure by Method B

Estimated reduction in radiation exposure rate = 0.53 mrem/min
Assuming a total cineangiography exposure time of 70 sec/procedure (10 coronary cineangiograms/patient × 7 sec of exposure/cineangiogram), the decrease in exposure/procedure would be:
0.53 mrem/min × 1.17 minute/procedure = 0.62 mrem/procedure
If a physician were to perform 500 procedures/year the decrease in exposure would be:
0.62 mrem/procedure × 500 = 310 mrem/yr

ommended during cardiac catheterization and were routinely used in this study [4]. When properly used, these devices can substantially diminish radiation exposure to the operator despite close proximity to the x-ray source. However, certain areas of the body including the upper extremities and head are difficult to protect. Therefore, we evaluated the effects of the extension device on exposure to the operator's hand which was closest to the x-ray source. Use of the extension connector device allowed the operator to increase distance from the radiation source and reduced hand exposure during coronary angiography. Although not specifically evaluated radiation exposure to other unshielded areas would likely decrease.

The radiation exposure rates calculated in this study may slightly overestimate the actual exposure rate. This occurred because the ring dosimetry chip was worn not only during cineangiography of the coronary arteries, but also during fluoroscopy when projections were aligned and coronary catheters were manipulated. However, the exposure time used for the calculation of exposure rate was derived only from the time of cineangiography exposure and neglected the time of exposure during fluoroscopy. Since the potential for exposure during fluoroscopy is lower and the measured cineangiography and total x-ray exposure times were not different for the 2 methods, this overestimation would have a minimal effect on the determination of the difference in exposure rate between the methods.

Because radiation exposure decreases in proportion to the square of the distance from the x-ray source, it has been recommended that all non-essential personnel leave the procedure room during cineangiography and those remaining in the room be located as far away as practical from the x-ray source [4]. The method described in this study exploits this principle to lower exposure to the operator. Implied in the description of this method is the requirement that the coronary catheter engage the ostium of the vessel in a stable and safe manner. Although situations may develop where it is necessary to manually control catheter position during cineangiography, this is usually unnecessary when preformed catheters are used from the femoral approach. Use of the extension tubing device does impose extra connections in the injection system and thus introduces an additional potential source for air or fluid leakage. Although this could occur, proper attention to the luer-lock fittings makes the actual risk of this complication negligible. In our experience with this device, which now exceeds 500 cases, air embolization has not occurred, catheter manipulations have not been more difficult, and there have been no complications directly related to the use of this device. Although it is difficult to recommend specific protective measures which are applicable to all procedures and laboratories, this simple modification could result in reduced long-term radiation exposure to medical personnel during diagnostic coronary cineangiography.

ACKNOWLEDGMENTS

The assistance of all cardiovascular technologists in the C.V. Richardson Cardiac Catheterization Laboratory of UNC Hospitals is gratefully acknowledged.

REFERENCES

1. Rueter FG: Physician and patient exposure during cardiac catheterization. Circulation 58:134–139, 1978.
2. Wold GJ, Scheele RV, Agarwal SK: Evaluation of physician exposure during cardiac catheterization. Radiology 99:188–190, 1971.
3. Gustafsson M, Lunderquist A: Personnel exposure to radiation at some angiographic procedures. Radiology 140:807–811, 1981.
4. Miller SW, Castronovo FP, Jr: Radiation exposure and protection in cardiac catheterization laboratories. Am J Cardiol 55:171–176, 1985.
5. Finci L, Meier B, Steffenino G, Roy P, Rutishauser W: Radiation exposure during diagnostic catheterization and single- and double-vessel percutaneous transluminal coronary angioplasty. Am J Cardiol 60:1401–1403, 1987.