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Radiation Exposure Among Scrub Technologists and Nurse Circulators During Cardiac Catheterization

The Impact of Accessory Lead Shields

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ABSTRACT

OBJECTIVES This study was performed to determine if the use of an accessory lead shield is associated with a reduction in radiation exposure among staff members during cardiac catheterization.

BACKGROUND Accessory lead shields that protect physicians from scatter radiation are standard in many catheterization laboratories, yet similar shielding for staff members is not commonplace.

METHODS Real-time radiation exposure data were prospectively collected among nurses and technologists during 764 consecutive catheterizations. The study had 2 phases: in phase I ($n = 401$), standard radiation protection measures were used, and in phase II ($n = 363$), standard radiation protection measures were combined with an accessory lead shield placed between the staff member and patient. Radiation exposure was reported as the effective dose normalized to dose-area product (E_{DAP}).

RESULTS Use of an accessory lead shield in phase II was associated with a 62.5% lower E_{DAP} per case among technologists (phase I: 2.4 [4.3] $\mu Sv/[mGy \times cm^2] \times 10^{-5}$; phase II: 0.9 [2.8] $\mu Sv/[mGy \times cm^2] \times 10^{-5}$; $p < 0.001$) and a 63.6% lower E_{DAP} per case among nurses (phase I: 1.1 [3.1] $\mu Sv/[mGy \times cm^2] \times 10^{-5}$; phase II: 0.4 [1.8] $\mu Sv/[mGy \times cm^2] \times 10^{-5}$; $p < 0.001$). By multivariate analysis, accessory shielding remained independently associated with a lower E_{DAP} among both technologists (34.2% reduction; 95% confidence interval: 20.1% to 45.8%; $p < 0.001$) and nurses (36.4% reduction; 95% confidence interval: 19.7% to 49.6%; $p < 0.001$).

CONCLUSIONS The relatively simple approach of using accessory lead shields to protect staff members during cardiac catheterization was associated with a nearly two-thirds reduction in radiation exposure among nurses and technologists. (J Am Coll Cardiol Intv 2017;■:■-■) © 2017 by the American College of Cardiology Foundation.

Recent reports of premature cataract formation, left-sided brain malignancies, subclinical atherosclerosis, and chromosomal damage among interventional cardiologists have heightened concerns over occupational radiation exposure in the cardiac catheterization laboratory (1-4). Recognition of these hazards has created demand for novel ways to reduce radiation exposure among interventional cardiologists (5-7). However, the hazards of radiation exposure in the catheterization laboratory are not limited to interventional cardiologists, as recent publications have suggested a possible increased risk for certain cancers, stroke, and cataracts among staff members (8-11). Considering these potential risks, additional studies are needed to better understand procedural characteristics that increase staff irradiation and to

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ABBREVIATIONS AND ACRONYMS

CI = confidence interval

DAP = dose-area product

E = effective dose

E_{DAP} = effective dose normalized to the dose-area product

FFR = fractional flow reserve

H_{os} = dose recorded by outer dosimeter

H_{osDAP} = dose recorded by outer dosimeter normalized to dose-area product

H_u = dose recorded by body dosimeter

H_{uDAP} = dose recorded by body dosimeter normalized to dose-area product

PCI = percutaneous coronary intervention

identify methods to reduce staff radiation exposure during cardiac catheterization.

It has been previously demonstrated that placing an accessory lead shield between the operating physician and patient effectively attenuates physician radiation exposure (12,13). Use of accessory shields to protect physicians from scatter radiation is now standard in many catheterization laboratories, yet similar shielding for staff members during cardiac catheterization is not commonplace. If using accessory shields to protect staff members were demonstrated to be effective, this approach might represent a relatively simple and inexpensive method to improve radiation safety in the catheterization laboratory. The present study was performed to identify procedural characteristics associated with radiation exposure among staff members during cardiac catheterization and to determine if the use of an accessory lead shield is associated with a reduction in radiation exposure among staff members.

METHODS

STUDY POPULATION. The SHIELD (Combining Robotic-Stenting and Proactive Shielding Techniques in the Catheterization Laboratory to Achieve Lowest Possible Radiation Exposure to Physicians and Staff) study was a single-center prospective observational study designed to investigate radiation exposure to physicians and staff members in the cardiac catheterization laboratory. The study was conceived, designed, and conducted by investigators of the Frederik Meijer Heart & Vascular Institute of Spectrum Health (Grand Rapids, Michigan). The local Institutional Review Board approved the protocol, and all participants provided informed consent.

Data were prospectively collected on consecutive cases in a single fluoroscopy suite with an Allura Xper FD10 x-ray system (Philips, Amsterdam, the Netherlands). All cases with start times between approximately 8 AM and 5 PM, Monday through Friday, were included in the study. Cases that did not require any radiation were excluded as specified in the study protocol. Radiation exposure data were collected on procedural staff members, including nurse circulators and scrub technologists. At the study institution, the nurse circulator is responsible for monitoring the patient, administering medications, and obtaining equipment requested by the operating physician. The technologist, who typically stands to the right of the operating physician, serves as a second operator during the case, assists the operating physician in device exchanges, performs all injections using a contrast delivery system (Acist CVi, Acist Medical Systems, Eden Prairie, Minnesota), and inflates angioplasty and stent balloons.

RADIATION MONITORING. Real-time radiation exposure data were collected using a commercially available dosimetry system that contains a bedside monitor capable of displaying real-time radiation exposure data (RaySafe i2, Unfors RaySafe, Billdal, Sweden). Physicians and staff members were blinded to the monitor display and to the radiation data collected by the dosimeters for the duration of the study. During the study, each staff member wore an outer dosimeter, located on either the left anterior side of the glasses or on the left anterior side of the thyroid collar, and a body dosimeter, located underneath the lead apparel on the V-neck of the scrub shirt.

RADIATION PROTECTION. According to standard operating procedure at the study institution, 2 shields were positioned between the patient and operating physician in all cases: a ceiling-mounted upper body lead shield with a patient contour cutout and a lower body lead shield attached to the side of the operating table extending from table to floor (12). A radiation-absorbing disposable pad (RadPad, Worldwide Innovations & Technologies, Kansas City, Missouri) was used at the discretion of the operating physician and staff members. Staff members wore traditional lead apparel, consisting of a lead skirt, apron, and thyroid collar.

To determine the impact of accessory shields on staff radiation exposure, the study was divided into 2 phases. During phase I, all cases were performed using the standard radiation protective measures described previously. In phase II, all cases were performed using standard radiation protective measures in combination with a dedicated accessory lead shield for each staff member. The accessory lead shields used in this study (height 1.8 m, width 0.7 m) had an effective lead thickness of 0.5 mm Pb. For nurse circulators, the shield was positioned between the patient and the intravenous medication pole. For scrub technologists, the shield was positioned near the foot of the bed, enabling them to stand behind the shield whenever possible, including while performing injections with the contrast delivery system (**Figure 1**).

STATISTICAL ANALYSIS. Using radiation exposure data collected from the outer dosimeter (H_{os}) and body dosimeter (H_u), the effective dose (E) per case