Operator Radiation Exposure During Percutaneous Transluminal Coronary Angioplasty

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Operator radiation exposure during percutaneous transluminal coronary angioplasty as compared with that during routine coronary angiography is unknown. Therefore, cumulative radiation exposure at operator eye level was measured in two physicians (operators 1 and 2) during performance of coronary angioplasty and routine coronary angiography. The physicians participated together during angioplasty in eight patients; they performed routine angiography separately in eight patients each.

Cumulative radiation exposure for eight angioplasty procedures was 140 mrad for operator 1 and 130 mrad for operator 2. In contrast, exposure during eight routine coronary angiography was 80 mrad for operator 1 and 60 mrad for operator 2. Mean cineangiographic time per case was similar (p = NS) during angioplasty (44.1 ± 14.0 seconds for both operators) and angiography (49.7 ± 6.1 seconds for operator 1, 47.6 ± 16.1 seconds for operator 2). In contrast, fluoroscopy time was longer (p < 0.01) for angioplasty (34.5 ± 17.7 min) compared with angiography (13.1 ± 5.1 min for operator 1, 13.7 ± 8.2 min for operator 2). Thus, operator radiation exposure during percutaneous transluminal coronary angioplasty was, on average, 93% greater than during routine coronary angiography and was related to the duration of fluoroscopy rather than cineangiography.

Radiation exposure to the operator during cardiac catheterization may limit the number of procedures a physician can perform safely (1–4). The advent of angiographic equipment with high output generators and X-ray tubes and the ability to perform easily angulated projections of the coronary circulation potentially increase radiation exposure to the operator, whereas the use of radiation protection devices decreases that exposure (5,6). However, a major determinant of operator radiation exposure necessarily remains the length of time spent during fluoroscopy and cineangiography.

Radiation exposure during percutaneous transluminal coronary angioplasty in comparison with that during routine coronary angiography has never been reported, but several aspects of coronary angioplasty (7) suggest that radiation levels may be considerably higher during this procedure than during routine coronary angiography. For example, 1) manipulation of the dilation catheter during angioplasty may require considerable fluoroscopy time; 2) adequate visualization of the stenosis and small side branches of the coronary artery during angioplasty may require biplane visualization, essentially doubling fluoroscopy time; 3) adequate visualization may also require the use of cranially or caudally angulated projections during the angioplasty procedure; and 4) it is common to perform either fluoroscopy or cineangiography for the entire duration of each balloon inflation during angioplasty. Therefore, we undertook the present study to compare operator radiation exposure during percutaneous transluminal coronary angioplasty and routine coronary angiography.

Methods

Cardiac catheterization protocol. All studies were performed in a cardiac catheterization laboratory equipped with a biplane LAD II P/A fluoroscopic imaging system interfaced with 2 MST-1050 II generators (General Electric). The patient was rotated on a cradle to obtain right and left oblique projections; the Fluoricon 300 ceiling-mounted anteroposterior image intensifier was tilted to obtain cranial and caudal projections. The lateral image intensifier and X-ray tube were ceiling-mounted and could not be rotated. Coronary angiography was performed at 6 inch (15 cm) magnification using a film speed of 30 frames/s. The two physicians participating in the study wore standard lead aprons, thyroid collars and lead eyeglasses during each procedure. The eyeglasses did not have side shields. To provide...
additional radiation protection, lead shielding was hung from the anteroposterior image intensifier (Fig. 1) and used during each procedure.

**Study phases. Phase 1: head exposure.** The study was carried out in two phases. During the first phase, radiation exposure was measured with a standard commercial film badge (Gardray 8) capable of detecting cumulative exposures as low as 10 mRads. Cumulative radiation exposure for each physician was measured with the film badge attached to the skin at eye level, but outside the protective field of the lead eyeglass. Radiation exposure was measured during a total of 24 coronary procedures. Operators 1 and 2 participated together in eight percutaneous transluminal coronary angioplasty procedures. Each served as the first surgeon in four procedures and as the assistant in the other four procedures. To compare radiation exposure during percutaneous transluminal coronary angioplasty with that during routine coronary angiography, operators 1 and 2 separately performed routine coronary angiography on eight patients each, again serving as first surgeon in four patients and as the assistant in four patients. In addition to cumulative radiation exposure, fluoroscopy time and cineangiography time were measured.

All patients having percutaneous transluminal coronary angioplasty and routine coronary angiography had right heart catheterization. Cranially and caudally angulated projections of the coronary circulation were obtained as necessary during both angioplasty and routine coronary angiography. In five of eight patients having angioplasty, it was necessary to use biplane fluoroscopy to visualize the coronary anatomy and dilation catheter system optimally. In these situations, the protective lead shield facing the lateral X-ray tube had to be removed (Fig. 2). Since both operators stood at the patient’s right side adjacent to the lateral X-ray tube and across from the lateral image intensifier, they were exposed to scatter radiation but not to the primary X-ray beam from the lateral fluoroscopy. We monitored balloon inflation during angioplasty with a brief burst of cineangiography followed by fluoroscopy until balloon deflation.

**Phase 2: eye exposure.** Because the radiation exposure measured during the first phase of the study actually determined exposure to the head and not to the eye itself, a second phase of the study was carried out. During this phase, operator 1 wore two thermoluminescent dosimeters. The first was attached to the skin just under the lower eyelid and was, therefore, protected by the lead eyeglasses; the second was attached to the left sidepiece of the eyeglasses (Fig. 3) and was, therefore, outside the area of protection by the lead eyeglasses. Radiation measurements from this latter dosimeter were assumed to be representative of exposure to the head. Cumulative radiation exposure to the eye and the head was measured during 34 coronary angiographic procedures.

**Study patients.** Of the eight patients having angioplasty, six had a left anterior descending artery lesion and two had a right coronary lesion. Angioplasty was successful in seven of the eight cases.

**Statistical analysis.** Analysis of variance was used to compare fluoroscopy and cineangiography time during angiography. In five of eight patients having angioplasty, it was necessary to use biplane fluoroscopy to visualize the coronary anatomy and dilation catheter system optimally. In these situations, the protective lead shield facing the lateral X-ray tube had to be removed (Fig. 2). Since both operators stood at the patient’s right side adjacent to the lateral X-ray tube and across from the lateral image intensifier, they were exposed to scatter radiation but not to the primary X-ray beam from the lateral fluoroscopy. We monitored balloon inflation during angioplasty with a brief burst of cineangiography followed by fluoroscopy until balloon deflation.

**Figure 1.** Angiographic equipment prepared for single plane angiography. The patient’s head is to the left. Two lead shields are draped from the anteroposterior image intensifier to provide additional protection from radiation scatter.

**Figure 2.** Angiographic equipment prepared for biplane angiography. The radiation protection shield that prevents lateral scatter has been removed from the anteroposterior image intensifier because it would have interrupted the lateral X-ray beam.
were not significantly different comparing the angioplasty group and the two groups of patients having routine coronary angiography.

Radiation exposure to the head compared with the eye. During the second phase of the study, mean fluoroscopy time was $9.6 \pm 6.1$ min and mean cineangiography time was $42.5 \pm 5.5$ seconds for the 34 cases. Cumulative radiation exposure to the skin was 140 mrad (4.1 mrad/case) compared with an exposure of 90 mrad (2.6 mrad/case) to the left eye. Thus, standard lead eyeglasses decreased the radiation exposure to the lens by approximately 35%.

Discussion

Role of fluoroscopy time. Previous work (1) has documented that fluoroscopy may account for approximately 50% of the radiation exposure incurred during cardiac catheterization. Consequently, our finding that percutaneous transluminal coronary angioplasty is associated with much higher operator radiation exposure than is routine coronary angiography is not surprising given the longer fluoroscopy times during angioplasty. Fluoroscopy time is, in part, determined by the operator’s skill in performing the procedure and, in part, by the technical difficulty of the case. At the time of this study, both operators had participated in approximately 30 coronary angioplasty procedures and were, thus, relatively inexperienced in the technique. On the other hand, all of the patients had single vessel proximal coronary artery disease of either the left anterior descending or right coronary artery, and none of the angioplasty procedures presented technical problems. With greater experience, our fluoroscopy time for cases of similar difficulty has decreased to less than 20 minutes, but we are now performing angioplasty in technically more difficult cases so that overall our fluoroscopy time has not changed.

Role of cranial and biplane projections. Two additional factors other than fluoroscopy time probably contributed to the higher radiation exposure during angioplasty. First, we performed biplane fluoroscopy during five of the angioplasty procedures, necessitating removal of one of the protection shields that was hung from the anteroposterior image intensifier (compare Fig. 2 with Fig. 1). Radiation scatter was probably considerably greater during these five cases, especially to the first operator who stood within 3 feet (0.95 m) of the lateral X-ray equipment. In contrast, we did not use biplane fluoroscopy for any of the patients undergoing routine coronary angiography. Second, we used cranial angulation for two of the angioplasty procedures during manipulation of the dilation catheter because an angulated projection was the only one that provided adequate visualization of both the coronary stenosis and coronary artery bifurcations. Although we obtained angulated views for all of the routine coronary angiograms, fluoroscopy time...
for the angulated projection was minimal during routine angiography.

**Role of radiation protection shields.** The fluoroscopy and cineangiography times for routine coronary angiography that we have reported here are within the range previously reported (1,5). Our operator radiation exposure levels were less than in some studies (1–4), but greater than in those that utilized specially designed radiation protection shields (5,6). Clearly, the type of radiation protection employed will strongly influence the level of operator radiation exposure; the shields we used (Fig. 1) allow substantial radiation scatter. It is probable that our results would have differed had we used a more extensive shield, such as that described by Gertz et al. (6).

The use of protective lead eyeglasses decreased the radiation exposure to the eye by about 35%, an important finding given that the lens is quite vulnerable to the long-term effects of ionizing radiation. However, Federal regulations (8,9) have identical limits of 5 rem for the allowed yearly occupational radiation exposure to the head and eye. Consequently, despite the benefits of lead eyeglasses, in the absence of more extensive shielding, in our laboratory it would be necessary to limit the number of angioplasty procedures to 5 cases/wk and not perform any other fluoroscopic procedures to meet the guidelines of an occupational exposure of 100 mRads/wk (8,9). Because radiation exposure is so much higher during percutaneous coronary angioplasty than during routine coronary angiography, institutions performing angioplasty should measure their operator radiation exposure levels to establish appropriate guidelines for their laboratories.

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**References**