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EDITORIAL COMMENT

Radiation Exposure in Medical Imaging

Is the Message Out or Just Being Ignored?*

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Radiation exposure from medical imaging has been receiving increased scrutiny in both the published medical data (1,2) and the lay press (3). To address this concern with the use of cardiac radionuclide imaging, the American Society of Nuclear Cardiology (ASNC) published a position statement in 2010 recommending that nuclear myocardial perfusion imaging (MPI) adhere to the principle of ALARA ("as low as reasonably achievable") and that by 2014, 50% of MPI studies should be performed with a radiation exposure of ≤9 mSv (4). A more recent publication from the ASNC recommends customizing the imaging protocol to the individual patient's characteristics to reduce radiation exposure (5). Despite these goals to reduce radiation exposure, there is little published data examining patient radiation exposure associated with imaging performed in nuclear cardiology laboratories (6).

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In this issue of *iJACC*, Jerome et al. (7) report the results of estimated radiation exposure from a nationwide sample of 5,216 MPI cases performed in 1,074 nuclear imaging laboratories submitted to the Intersocietal Accreditation Commission. This survey data provides several interesting findings. The mean effective dose was 14.9 ± 5.8 mSv, with a range of 1.4 to 42.4 mSv. Only 1.1% of cases met the ASNC goal of ≤9 mSv. Conversely, radiation exposure exceeded 20 mSv in almost 10% of cases. The large majority (82.9%) of cases used a 1-day technetium^{99m} protocol. In these cases, the mean effective dose was 12.9 mSv, 2 mSv lower than the mean effective dose in the entire study group. Thallium^{201} was administered in only 9.1% of cases. As anticipated, the mean effective dose for thallium^{201}-only studies was higher than technetium^{99m} cases, at 23.9 mSv. The mean effective dose was the highest for dual (thallium^{201}/technetium^{99m}) isotope studies at 32.8 mSv.

This study by Jerome et al. (7) represents a novel and important contribution to the published data. This report is the first systematic description of radiation exposure associated with cardiac MPI. The authors were able to take advantage of the Intersocietal Accreditation Commission database and capture use from all regions of the country and from multiple types of medical practices.

What do these data teach us? Studies addressing radiation exposure need to be interpreted cautiously, given the scientific uncertainty associated with this topic. At face value, the results of this study might suggest that the medical community is doing a poor job of addressing this issue, because only 1% of the studies performed met the ASNC threshold of ≤9 mSv. A potential implication of this observation is that a large number of patients might be placed at increased risk of developing complications related to radiation exposure, with malignancy representing the greatest concern. However, there are several important issues that should be considered when interpreting the results of this study. First, the 9-mSv threshold is an arbitrarily derived value. There is no direct data that determines when cancer risk might increase for radiation exposure associated with medical imaging. It is possible that there is no difference in cancer risk between exposure of the ASNC threshold of 9 mSv and the mean effective dose in this study of approximately 15 mSv. Second, the mean effective dose in the majority of the population who underwent 1-day technetium^{99m} scans was approximately 13 mSv, closer to the 9 mSv threshold and a fairly modest difference when interpreted in the context of average annual background radiation exposure for the general U.S. population of 3 mSv. The greatest discordance was in the 10% of cases where exposure was >20 mSv.

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Evaluating the potential cancer risk associated with radiation exposure is a complex issue. Radiation exposure should be interpreted not in isolation, but instead in the clinical context of the patient in whom the imaging study is performed. Factors such as patient age, weight, and other medical testing play a role in cumulative exposure. A limitation of the study by Jerome et al. (7) is that important clinical data were missing, especially the appropriateness of the study, age of the patient, body habitus, and prior radiation exposure. Patients who are undergoing MPI for an appropriate indication are at higher cardiac risk. The value of the knowledge gained from the MPI scan for correct management of the patient likely far outweighs the small theoretical radiation-associated cancer risk. Radiation exposure is of greater concern in younger than older patients, given that the estimated latency period between exposure and appearance of cancer is at least 10 to 20 years (4). As an example, an 80-year-old patient who is undergoing a single MPI scan is less likely to see a clinically relevant increase in malignancy risk from the test's radiation exposure compared with a 40-year-old patient. Image quality is directly related to the amount of radioisotope administered. The most common issue adversely affecting image quality is soft tissue attenuation in obese patients. It is generally preferable to administer a higher dose of radioisotope and obtain images of good quality than to administer a lower dose with suboptimal images. Image quality can be enhanced by performing a 2-day versus 1-day MPI study, albeit with higher radiation exposure. It would be interesting to know the average body mass index, in particular for the 7.5% of patients who underwent 2-day MPI in this study. Because cancer risk associated with radiation exposure is likely cumulative, it would be helpful to know information on prior MPI studies as well as other imaging procedures associated with radiation in these patients. This information was not provided in the current study but should be included in future studies that address this topic.

Although considerable uncertainty exists concerning radiation exposure and cancer risk, measures to limit radiation exposure are reasonable and prudent and are recommended by several national organizations (1,2). The study by Jerome et al. (7) provides a useful starting point for addressing this objective. The mean effective dose in the 1.6% of the population who underwent thallium^{201}-only MPI was 23.9 mSv, and it was especially high, at 32.8 mSv, in the 7.5% of the population who underwent dual isotope imaging. Discouraging the routine use of this radioisotope should be strongly encouraged, especially when used in a dual isotope algorithm. Another approach to reduce radiation exposure is to perform a stress only protocol. In this study, that modality was utilized in only 1.4% of the population. Wider application of this protocol should be feasible, especially in light of recent reports of normal image rates of 80% to 90% in patients without an established history of coronary artery disease (8,9). The use of ultrafast single-photon emission computed tomography (SPECT) and positron emission tomography (PET) imaging methodologies are associated with lower radiation administration. Ultrafast SPECT camera technology provides greater flexibility for choosing between radioisotope dosage and imaging time. PET imaging is associated with lower radiation exposure due to the short half-lives of the PET perfusion isotopes (rubidium^{82} and ammoni^{13}). Average exposures of 2 to 3 mSv are readily achievable with these approaches. The lowest radiation exposures in this study were noted with the newer ultrafast camera technology. Implementing these approaches can be logistically challenging and more expensive for individual cardiac imaging laboratories. The authors' call for performance standards and possibly financial incentives should lead to greater implementation of these measures. Finally, the performance of MPI and all noninvasive cardiac imaging should be carefully scrutinized according to appropriate use criteria documents (10,11) and national guidelines (12). In particular, younger patients, who have a higher cancer risk from radiation exposure, are more likely to be capable of adequate exercise and have a normal electrocardiogram. Most of these individuals can be satisfactorily assessed with a standard treadmill test without imaging.

We believe that the message is out to clinicians that radiation exposure in medical imaging must be decreased. The paper by Jerome et al. (7) indicates that current practice patterns need to be altered to successfully translate this message into practice. Continued education programs, technological advancements, and regulatory changes will all play a role in attaining lower radiation exposure associated with cardiac imaging.

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