EDITORIAL COMMENT

Health Effects of Medical Radiation on Cardiologists Who Perform Cardiac Catheterization

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Occupational doses from fluoroscopy-guided interventional procedures are the highest doses registered among medical staff using X-rays.[1] Interventional cardiologists who work in cardiac catheterization laboratories are exposed to low doses of ionizing radiation that could pose a health hazard. Cardiac catheterization has been used for decades and is the gold standard for the diagnosis of different cardiovascular diseases. Cardiovascular interventional therapy is effective therapeutically for cardiovascular diseases and reduces the morbidities of coronary artery disease, peripheral vascular disease, cardiac arrhythmia, and congenital heart disease. However, interventional cardiologists working in high-volume cardiac catheterization laboratories are exposed to significant occupational radiation risks of developing certain diseases, including hematopoietic cancers, thyroid diseases, skin diseases, cataracts, or upper respiratory disease (URI).[2] Controversial data have been reported about the relationship between the amount of radiation exposure and development of different diseases after cardiac catheterization and interventional procedures.[3,4]

To reduce and prevent radiation-associated diseases, the amount and duration of radiation exposure that may be harmful to the interventional cardiologist should be well defined. In addition, strategies to prevent and monitor radiation exposure, including new fluoroscopic equipment with lower radiation doses, advanced protective shielding, and effective radiation monitoring methods, should be applied by current interventional cardiologists.

Yuan et al reviewed and analyzed the illnesses of cardiologists in Taiwan from 2003 to 2006, and evaluated if radiation exposures were correlated with disease.[5] Their results showed that the number of medical visits for blood and thyroid cancers, skin-related diseases, and URI was higher in younger doctors (35–50 years old) who did not perform cardiac catheterization compared to those who did. The number of medical visits for skin-related diseases and URI was also higher for the older doctors (51–65 years old) who did not perform cardiac catheterization compared to those who did. Among those younger cardiologists who performed more cardiac catheterizations than older cardiologists, there was no trend towards more cancer or cataracts. According to Yuan et al's report, there was no correlation between radiation exposure and certain radiation-associated diseases. However, there were some limitations in their study. First, the data were limited to 4 years (2003 to 2006), and there was no natural cross section. Damage caused by radiation exposure may develop after long-term accumulation or only observed during long-term follow-up. Some cancers or cataracts may develop later, after 4 years of follow-up, and disease seen during the observational period may be the consequence of older cardiologists carrying out cardiac catheterizations previously. Second, the relationship between performing cardiac catheterization and cancers/cataracts should be correlated with the total accumulated previous doses of radiation exposure. Therefore, the total radiation exposure to doctors, the fluoroscopy-associated radiation experienced, and the numbers and years of cardiac catheterization performed should be collected for each cardiologist. Third, the records used in the study were from the database of the Bureau of National Health Insurance, Republic of China, and did not reflect the real disease entities of all cardiologists in Taiwan. In addition, the total numbers of cardiologists enrolled in this study did not appear to be correct. In this study, there were 2,292 cardiologists in Taiwan, and 892 of them performed cardiac catheterization from 2003 to 2006. In fact, the members of the Taiwan Society of Cardiology only number 1,000, and fewer than 500 cardiologists perform cardiac catheterization.

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With regard to the relationship between performing cardiac catheterization and cardiac catheterization-related diseases, previous studies have indicated that multiple factors may be involved. As for the pathophysiology, DNA damage is considered to be the main initiating event by which radiation damage to cells results in development of cancer and hereditary disease. Andreassi et al assessed the effects of chronic low-dose X-ray radiation exposure on somatic DNA damage in interventional cardiologists working in high-volume cardiac catheterization laboratories.[6] They used peripheral lymphocytes and the assay for micronuclei (MNs), which is considered to be a reliable biological dosimeter for radiation exposure. Peripheral blood was collected from 62 physicians (mean age ± standard error, 40.6 ± 1.5 years): 31 interventional cardiologists (group I, exposed) and 31 age- and sex-matched clinical cardiologists (group II, non-exposed). Interventional cardiologists showed higher MN values (group I = 20.5 ± 1.6 *vs.* group II = 12.8 ± 1.3; $p = 0.001$) than did clinical cardiologists. There was a correlation between years of professional activity and MN frequency values for the interventional cardiologists ($r = 0.428$, $p = 0.02$) but not for the clinical cardiologists ($r = 0.253$, $p = 0.17$). Andreassi et al[6] also suggested that common single-nucleotide polymorphisms in DNA repair genes modify the effects of low-dose radiation exposure on DNA damage, which is the main initiating event in the development of cancer and hereditary disease.[7] They enrolled 77 subjects: 40 interventional cardiologists (27 males, 41.3 ± 9.4 years old; 13 females, 37.8 ± 8.4 years old) and 37 clinical cardiologists (26 males, 39.4 ± 9.5 years old; 11 females, 35.0 ± 9.8 years old) without radiation exposure as the control group. Within the exposed group, individuals carrying the XRCC3 Met241 allele had a higher frequency than homozygous XRCC3 Thr241 (21.2 ± 7.8 per 1,000 *vs.* 16.6 ± 7.1 per 1,000; $p = 0.03$). Individuals with 2 or more risk alleles showed a higher MN frequency compared with subjects with 1 or no risk alleles (18.4 ± 6.6 per 1,000 *vs.* 14.4 ± 6.1 per 1,000; $p = 0.02$). An interactive effect was found between smoking, exposure > 10 years and the presence of 2 or more risk alleles on the MN frequency ($F = 6.3$, $p = 0.02$). Andreassi et al concluded that XRCC3 241Met alleles, particularly in combination with multiple risk alleles of DNA repair genes, contribute to chromosomal DNA damage levels in interventional cardiologists.

The intervention approach strategy also influences radiation exposure. Brueck et al evaluated the safety, feasibility, and procedural variables by the transradial approach compared with transfemoral access in a standard population of patients undergoing coronary catheterization.[8] A total of 1,024 patients undergoing coronary catheterization were randomly assigned to transradial or transfemoral approach groups. The median procedural duration [37.0 minutes, interquartile range (IQR) of 19.6–49.1 minutes *vs.* 40.2 minutes, IQR of 24.3–50.8 minutes; $p = 0.046$] and median dose area product (38.2 $Gycm^2$, IQR of 20.4–48.5 $Gycm^2$ *vs.* 41.9 $Gycm^2$, IQR of 22.6–52.2 $Gycm^2$; $p = 0.034$) were significantly lower in the transfemoral group compared with those in the transradial access group.

With regard to the methods for reducing radiation exposure in interventional cardiologists, several strategies should be attempted. First, new-generation cardiac catheterization machines with lower doses of radiation generated should be used.[9] Second, operators should use simpler diagnostic and interventional procedures with less fluoroscopic time and single-plane projection to reduce unnecessary radiation exposure.[10,11] Third, optimization of radiation protection devices for operators is achieved by minimizing the effective dose (E).[12] A lead apron of 0.35 mm or 0.5 mm thickness reduces E to 14.4% or 12.3%, respectively; by using an additional thyroid collar, these values are reduced to 9.7% or 7.5%. A thyroid collar reduces E by more than an increase of the lead equivalency of the existing apron. Wearing an apron of 0.5 mm lead-equivalent with a thyroid collar and using an additional side shield results in a decrease in E to 6.8%. The use of both a fixed side shield and a face shield decreases E to 2.0%. In addition, the use of a lead glass screen against scatter radiation to the eyes in interventional cardiologists effectively protects the eyes from radiation.[12]

In conclusion, accumulation of radiation doses to interventional cardiologists may increase DNA damage and could ultimately result in cancers or certain diseases in some individuals. To prevent radiation-associated diseases, radiation exposure in interventional cardiologists should be reduced by using new-generation cardiac catheterization machines with less radiation, performing simpler diagnostic and interventional procedures with shorter fluoroscopic times, and using effective shielding to protect from radiation damage.

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