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Editorial

Editorial: Ionizing Radiation—The Unseen Enemy of Structural Heart Disease Interventions

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Structural heart disease intervention is a growing field encompassing numerous valvular procedures, novel interventions for heart failure, and treatment of congenital heart disease to name a few. The majority rely on the "heart team" for patient evaluation and treatment decision-making to optimize patient outcomes. In addition, many of these procedures utilize a procedural heart team including at least one interventional cardiologist, cardiac surgeon, interventional echo imagers, and anesthesia. These members are crucial for patient monitoring, procedural imaging, and execution. Their addition to the hybrid operating room or cardiac catheterization lab has added significantly to structural heart disease interventions and permitted important developments in the field to treat patients. For these members of the heart team however, there has been the added exposure to a previously unfamiliar partner, ionizing radiation.

Interventional cardiologists are no strangers to ionizing radiation, ranking among health professionals with the highest exposure. An understanding of radiation exposure, including the basic terminology, is essential to comprehend the risks of radiation-induced injury. The effective radiation dose, measured in millisieverts (mSv), is the dose received by the whole body regardless of where the radiation is delivered. For example, the average effective dose of a diagnostic coronary angiogram is between 2 and 16 mSv although this increases in the setting of a percutaneous coronary intervention (PCI). To put this into perspective, the average annual background radiation exposure to a person living at the sea level is approximately 3 mSv. In addition to the effective dose, most catheterization laboratory equipment measures air kerma, the energy delivered to a certain point in space in gray (Gy) or milligray (mGy), and dose area product (P_{KA}) which accounts for the area of the beam of radiation exposure (Gy*cm^2).

Structural procedures tend to be longer than standard diagnostic procedures or interventions and, therefore, may be associated with increased radiation doses for the patient and the procedural team. In fact, the amount of radiation exposure in patients undergoing transcatheter aortic valve replacement (TAVR) by either transfemoral or transapical approach has been previously compared to that of patients undergoing PCI. In this study of 105 TAVR patients, radiation use was compared to patients at the same institution undergoing PCI with a higher median radiation dose of PCI but a lower dose area product than TAVR. In comparison to transfemoral TAVR, transapical TAVR was found to have significantly lower doses of radiation for the patient. This was felt to be due to increased fluoroscopy time for vascular access management.[1]

In this issue of Structural Heart, Goel et al.[2] describe the radiation exposure of operators performing transfemoral TAVR in a hybrid operating room under echocardiographic guidance. This single-center experience evaluated operator radiation exposure during standard transfemoral TAVR without the use of additional radioprotection such as the RADPAD or cerebral protection device implantation. Two operators were assessed during the intervention: the primary operator (operator 1) standing closest to the imaging tube and the operator assisting (operator 2). Practices to reduce radiation exposure included fluoroscopy at 7.5 frames/s, minimal cine imaging, and use of predominantly antero-posterior and slight right anterior oblique imaging for most of the procedure. Radiation exposure was measured using real-time dosimeters, and the effective dose was expressed in microsieverts (μSv). In this study of 140 transfemoral TAVR patients, the investigators found that in comparison to the second operator, primary operators had a higher cumulative effective radiation dose (67 μSv vs. 22 μSv, $p < 0.0001$). Patient factors such as obesity and procedural complications were also associated with an increased radiation dose to the operators and have been previously documented as predictive of increased radiation exposure to patients.[3]

This study is interesting in that it documents the radiation exposure of physicians performing TAVR and illustrates what has been assumed, the

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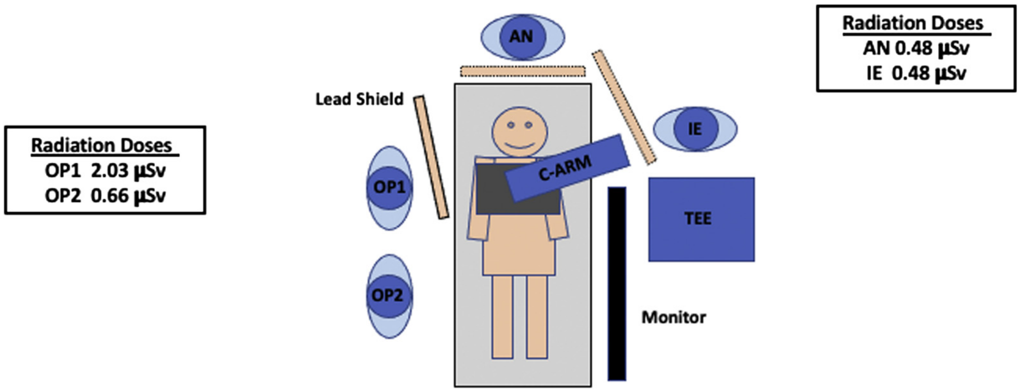

Figure 1. Radiation doses of patients during interventional procedures. Radiation doses for operator 1 and 2 as described in the study by Goel et al.[2] Radiation doses for AN and IE as described in the study by Crowhurst et al.[6] Abbreviations: AN, anesthesiologist; IE, interventional echo imager; OP1, operator 1; OP2, operator 2; TEE, transesophageal echocardiography.

operator closest to the radiation source is exposed to higher doses of radiation. It is, however, less representative of actual practice, given the limited angulations used, which likely underestimates true radiation exposure to the operators. Finally, although this is instructive for transfemoral TAVR, alternative access TAVR is associated with significantly higher doses of radiation owing to challenges with use of shielding.[4]

Another missing component is the radiation exposure to the other procedural team members, including the anesthesiologist and interventional echocardiographer. The structural procedural team, as previously mentioned, contains multiple members, all of whom have exposure to ionizing radiation during the procedure. Their individual risk is clearly related to their location and proximity to the radiation source during the procedure. In Figure 1, the most common locations of the team members are depicted as well as their proximity to the radiation source. Such factors affect the radiation exposure to these team members which should also be measured and evaluated on an annual basis. In addition, strategies to reduce radiation exposure should be evaluated and implemented as appropriate.

In a small study of radiation exposure to anesthesiologists during transfemoral TAVR, the use of a lead cap was evaluated to reduce radiation exposure to the head. During a period of 15 days which comprised 32 TAVR procedures, the maximum dose of 0.55 mSv was recorded from a dosimeter placed on the outside of a lead cap placed on the head. The dose measured on the inside of the cap during the same interval was 0.08 mSv.[5] Lead shields are often placed at the head of the patient to protect the anesthesia team; however, they may interfere with patient care; therefore, they are often displaced during the procedure. This may result in significant radiation exposure which may be reduced by additional personal shielding in the form of a lead cap.

Similar data regarding radiation exposure have been published for interventional echocardiographers performing structural procedures such as left atrial appendage occlusion and mitral valve repair in addition to TAVR. The interventional echocardiographer is often located on the left side of the patient near the head where there may be little ceiling-mounted lead shielding. In a study of 98 structural procedures, the amount of radiation exposure was evaluated in the procedural team which comprised of an anesthesiologist, a transesophageal echocardiography (TEE) operator, primary operator 1, and operator 2. The effective dose of radiation measured was highest in the TEE operator (2.62 µSv), followed by operator 1 (1.91 µSv), operator 2 (0.48 µSv), and the anesthesiologist (0.48 µSv). The addition of a lead shield to protect the TEE operator was associated with a significant reduction in the effective dose to equal that of the second operator (2.62 µSv [interquartile range: 0.95-4.76] to 0.48 µSv [interquartile range: 0.00-1.43 µSv] [$p < 0.001$]).[6]

Structural heart interventions continue to increase and advance, offering patients new therapies, but these require a dedicated team and for the most part, the use of ionizing radiation in addition to echocardiographic imaging to perform them. Previously the unseen enemy of interventional cardiologists alone, ionizing radiation has now become something of importance for the cardiac surgeon, interventional echocardiographer, and anesthesiologist. The structural team must work together to implement strategies to reduce radiation exposure to all members of the team including the patient during these procedures. New imaging advances including fusion imaging have been shown to reduce radiation for endovascular procedures and may have promise in the structural realm as well.[7] In the meantime, a concerted effort to reduce radiation exposure for all is paramount.

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