Minimizing Exposure, Maximizing Safety: Cath Lab Radiation Protection

Balancing safety, comfort, and operational efficiency in a high-risk environment.

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In the cardiac catheterization lab (CCL), physicians and staff are exposed to ionizing radiation during diagnostic coronary and peripheral angiography, as well as interventional procedures. These procedures include percutaneous coronary intervention, peripheral interventions, transcatheter aortic valve replacement, edge-to-edge mitral and tricuspid repair, left atrial appendage closure, patent foramen ovale, and atrial septal defect, in addition to electrophysiology. The risk of radiation exposure to health care workers is a significant concern, with long-term exposure leading to an increased risk of developing cancer (eg, brain tumors, breast cancer, skin cancer), cataracts, cognitive degradation, thyroid dysfunction, and other health complications.[1,2] Therefore, the use of radiation protection devices is essential in minimizing exposure while ensuring procedural success. This article reviews the pros and cons of personal radiation protection devices and stationary shielding systems, along with the importance of technology for monitoring radiation exposure.

PERSONAL RADIATION PROTECTION

Lead Aprons and Thyroid Shields

Lead aprons and thyroid shields are the most widely used personal protection devices in the CCL. They are designed to protect health care workers from scatter radiation during procedures. Lead aprons can attenuate up to 95% of radiation exposure, providing significant protection.[3] Lead aprons should cover the body from the neck to the knees to effectively shield the individual wearing it. Currently, 0.5-mm lead/lead-equivalent aprons are considered standard.[4] It is also important to regularly check the condition of the lead apron, as wear and tear can reduce its effectiveness. When selecting a lead apron, it is essential to consider factors like weight, comfort, and size and ensure it provides adequate coverage without hindering mobility. Thyroid shields offer high protection for the thyroid, reducing the risk of radiation-induced thyroid cancer or thyroid dysfunction.[5] They can be easily combined with a lead apron without interfering with movement.

Unfortunately, lead aprons can be heavy, causing discomfort and fatigue for health care workers, especially during long procedures. Over time, this can lead to orthopedic injury or exacerbation of prior orthopedic injuries.[3] The weight can also limit normal mobility and flexibility.[3] Thyroid shields also only protect the thyroid area and need to be appropriately fitted. If too large or too small, scatter can still reach the thyroid. Periodic inspection and proper maintenance are crucial for ensuring its protective capacity.[3]

Lead Glasses

Lead glasses are essential for protecting the eyes, which are highly susceptible to radiation-induced issues, especially cataracts.[6] Lead glasses with a 0.25-mm lead equivalent can provide significant protection from radiation to the front of the eyes, a critical area for medical professionals exposed to radiation regularly.[7] Some styles are relatively lightweight, allowing for longer use without significant discomfort. Standard glasses provide only 30% to 35% attenuation, while plastic lenses offer minimal radiation protection.[7] It is important to note that interventionalists often turn their heads away from the primary beam to view the fluoroscopy monitor during exposure; therefore, protective eyewear should also provide shielding for side exposure. This can be done with either side shields or a wraparound design.[4] However, glasses only protect the eyes and do not protect the rest of the head or body from radiation exposure.

MAVIG Shields

MAVIG shields (MAVIG GmbH) are portable, adjustable shields designed to protect the body from scatter radiation. These shields can be positioned to cover different areas of the body as needed during procedures. When positioned properly, they can shield against a significant amount of scatter radiation. Table-mounted shields with a typical lead-equivalent thickness of 0.5 mm protect the lower extremities from scatter. Properly positioned, these shields can attenuate > 90% of scatter.[8]

Ceiling-mounted protective barriers (typically 0.5-mm lead equivalent) are positioned to shield the upper body and extremities. Effective placement close to the operator and tight to the patient's surface can provide significant protection.[8] They primarily shield the torso but can easily leave areas exposed, such as the face and arms, particularly if not repositioned regularly. The need to reposition these can lead to disruption of the case, and one can also forget to reposition.

Minimizing Fluoroscopy and Cine Frame Rates

Reducing fluoroscopy and cine frame rates can significantly decrease radiation exposure by limiting the number of x-ray images taken during a procedure. By adjusting frame rates, the system can maintain image clarity while reducing unnecessary radiation.[9] However, this can require an adjustment for the operator and team if they are not comfortable with completing procedures at lower frame rates. Unfortunately, lower frame rates might result in a loss of real-time detail, which may require supplementary information including but not limited to intravascular imaging.

Collimation

Collimation narrows the x-ray beam to focus only on the area of interest, minimizing exposure to surrounding tissues and reducing the area exposed to radiation. This can lead to significant dose reductions and provide clearer images by focusing the radiation on the area of interest.[10] Adjusting collimation settings requires careful setup and constant adjustment during the procedure and may not be feasible for all types of procedures.

RadPad

The RadPad (Worldwide Innovations & Technologies, Inc.) is a disposable, lead-free pad used to shield the patient and health care staff from scatter radiation. They are easy to handle and move compared to traditional lead aprons, providing protection without causing excessive fatigue. They attenuate a significant amount of scatter radiation.[11]

STATIONARY RADIATION PROTECTION

Whole-body radiation protection devices are evolving for the CCL and other labs where radiation is frequently used, including operating rooms and neurology and gastroenterology suites. These barriers again have lead thickness ranging from 0.5 to 2 mm and can be transparent and mobile, allowing for a more adaptable approach to radiation protection.[4] Studies have shown these devices to be effective in attenuating scatter radiation. Even when differences in lead thickness were measured, the absolute reduction in scatter radiation consistently exceeded 90%, emphasizing their significant role in reducing radiation exposure to those in the CCL.[12] As a result of this reduction, these mobile barriers can minimize the risks associated with radiation exposure, significantly improving the safety of health care professionals working in the CCL.

Rampart System

The Rampart system (Rampart) is a modular, lead-free radiation protection system designed to shield CCL staff during procedures. It can be adjusted to suit various procedural setups, ensuring effective protection against scatter radiation. The shield can be attached to a boom arm or ceiling or alternatively can be on a stand with wheels to allow for easy mobility from room to room. The system includes a large, adjustable screen that can be positioned between the operator and the radiation source. The shield is designed to provide protection for health care workers, including those standing near the radiation source and at various positions within the CCL.[13] Rampart exceeds 90% reduction in radiation exposure for operators, especially those working in proximity to the fluoroscopy machine. The Rampart Defender mobile shielding solution allows for flexibility in use, ensuring it can be repositioned quickly depending on the needs of the procedure. The newer Guardian model provides protection for the entire room.

Radiaction System

The Radiaction system (Radiaction Medical) attaches directly to the C-arm imaging device to proactively block scatter radiation at its source, providing protection for the entire interventional team. It is a modular, mobile protection solution that uses suspended panels to provide real-time radiation protection. The system is adaptable to different procedure types and offers high radiation protection levels.[14] It is also lead-free, reducing weight and improving maneuverability. However, the system can be expensive, making it a significant investment for some health care facilities.

Zero-Gravity

The Zero-Gravity system (TIDI Products, distributed by Biotronik) suspends lead aprons using a counterweight mechanism, relieving the operator from carrying the weight during procedures. It provides more mobility compared to

traditional lead aprons and has been shown to reduce operator radiation exposure.[15] However, this system only protects the person using the device, and proper installation and adjustments take time.

Protego System

The Protego system (Image Diagnostics Inc.) involves a combination of leaded glass panels and flexible shields, providing comprehensive protection. The device's modular design makes it adaptable to various procedural setups. Its shielding capabilities have been demonstrated to significantly reduce radiation exposure, especially in areas where personnel are most likely to encounter scatter radiation.[16]

EggNest

The EggNest (Egg Medical) is a protective dome or cover that surrounds the patient, offering a "nest" of protection that can be adjusted based on patient positioning. It effectively blocks radiation exposure from above and from the sides. By encapsulating the area surrounding the patient, the device reduces the amount of scatter radiation that reaches health care workers and the patient. It similarly provides significant protection for personnel, especially during lengthy diagnostic or interventional procedures.[17]

RADIATION DOSE MONITORING

The RaySafe radiation dose monitoring system (RaySafe) provides real-time data on radiation exposure for patients and medical staff. It provides immediate feedback on radiation levels, allowing health care workers to adjust their technique if exposure is too high. Purchasing the RaySafe system is an investment up front but after proper training can help ensure appropriate use of shields and reduce the risk of being affected by scatter.[18]

CONCLUSION

Radiation protection in the CCL is crucial for safeguarding health care workers from the harmful effects of radiation. Personal protection devices, such as lead aprons, glasses, and thyroid shields, provide foundational protection, while advanced systems like Rampart, Radiaction, EggNest, Protego, and Zero-Gravity offer additional safety, comfort, and mobility. Techniques such as minimizing fluoroscopy frame rates, collimation, and use of RadPad further contribute to reducing radiation exposure. Finally, real-time radiation dose monitoring via RaySafe enhances radiation safety by providing actionable data. Although each device and system has advantages and limitations, a combination of these strategies helps ensure the highest levels of protection for staff and patients in the CCL. ■

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