ALARA+: Making "Less and Lower" Work in the Cath Lab

Insights into a collaborative, multisociety approach to reducing radiation exposure with an emphasis on ensuring musculoskeletal health and how to make it feasible in the everyday setting.

With Amit N. Vora, MD, MPH, FACC, FSCAI

Fluoroscopy-guided procedures are integral to modern interventional practice, but they expose clinicians and staff to cumulative radiation risks as well as significant orthopedic strain associated with traditional protective equipment. Recognizing these dual hazards, a "Think Tank" convened at the Society for Cardiovascular Angiography & Interventions (SCAI) Annual Scientific Sessions meeting comprising a multidisciplinary group of stakeholders—including interventional physicians, radiologists, nurses, technologists, medical physicists, health care administrators, industry representatives, and professional society leaders—to evaluate current challenges and identify opportunities for improvement. Professional society representation included SCAI, the Alliance of Cardiovascular Professionals, American College of Cardiology, American Society of Echocardiography, Heart Rhythm Society, Occupational Radiation Safety in Interventional Fluoroscopy, Society of NeuroInterventional Surgery, Society of Interventional Radiology, Society for Pediatric Radiology, Society for Vascular Surgery, and Society of Vascular and Interventional Neurology. These discussions were summarized in published guidance in multiple journals.[1]

Cardiac Interventions Today talked with Dr. Amit N. Vora to discuss the concept of ALARA+ (as low and light as reasonably achievable), key themes from the discussions, and actionable strategies that enhance radiation safety, reduce musculoskeletal (MSK) injury, and promote a more sustainable and equitable workforce within the cath lab and operating room.

Traditional radiation safety has focused primarily on dose reduction, but the ALARA+ framework expands this to include minimizing orthopedic strain and long-term occupational risk. How do you implement the concept of ALARA+ in your daily practice? What are the most important modifiable risk factors for MSK injury, and how can they be realistically addressed?

The concept of ALARA+ was developed as part of a reimagining of safety in the fluoroscopic labs. Previously, the only real equipment available for protection was limited fixed shielding and personal protection garments (lead-equivalent aprons). In that setting, the available protection followed the basic principles of radiation safety: limiting fluoroscopic time, increasing distance from the imaging equipment, and personal shielding. However, there was a tradeoff between radiation protection and MSK injury; indeed, at the SCAI Think Tank we heard numerous shared personal stories of intractable neck/back pain and radiculopathy.

Thankfully, the field has progressed significantly over the past decade in terms of additional options available to protect operators and cath lab staff. Contemporary imaging systems can process imaging and provide clear pictures with much less radiation exposure. There are expanded personal protection equipment options and new innovations for suspended garments. We also have moveable shielding systems available such that operators no longer have to even wear personal protective equipment.

To that extent, the goalposts have shifted away from the (relatively) minimal protection offered from first-generation systems to a more comprehensive array of tools that can substantially reduce radiation exposure and minimize both the weight of wearing lead and the corresponding MSK risks.

ALARA+ is a recognition that what was "as low as reasonably achievable" is different now than it was 20 years ago—we now have the technology to much more significantly reduce radiation exposure, with the additional benefit of minimizing MSK risks.

The Think Tank highlighted that delayed or infrequent dosimetry reporting limits behavior change, whereas real-time feedback can immediately influence operator decisions. What role should real-time dosimetry play in modifying operator behavior during procedures?

As you can imagine, what we ask operators and staff in the cath lab to do is extremely challenging. We want people to wear lead to protect against an invisible risk that can potentially be deadly but manifest decades later. We wear a badge that can track radiation, but reports often come back months after the exposure. Often, if the exposure is below the arbitrary regulated amount (it should be noted that no amount of radiation is safe), these data are not relayed back to operators in a timely manner. Although commercially available, real-time dosimetry monitors are not required by current regulations.

The times I have found these monitors to be most helpful is when trialing different radiation strategies. It is eye-opening the amount of radiation exposure reduction the current-generation systems can provide. High-exposure readings can lead to reevaluation of the current setup to identify areas where radiation may be leaking and, in more extreme cases, may lead to procedural changes (eg, staged procedures). These changes can also help in changing gantry angles to ensure visualization but reduce radiation.

What factors should guide adoption of enhanced radiation protection devices or newer imaging technologies? How can barriers such as cost and institutional pushback be effectively navigated to drive adoption?

The main factor is a recognition that places workplace safety at the epicenter of these decisions. There is no question that these systems are costly, at least on a line-item basis. But losing a high-volume operator for health reasons can also be extremely costly from a programmatic perspective. Not being able to hire talented operators and staff because the lab is not equipped with contemporary safety equipment can be costly as well. Additionally, now that our procedural staff has grown to include anesthesiologists and interventional imaging specialists (who are traditionally even less protected than operators), it is critical to ensure that worker exposure is as low as possible. We cite data in the paper on some of these costs.

The most important aspect of more widespread adoption of these technologies is partnership with the administration and staff in identifying specific challenges to institutional adoption and designing strategies to mitigate them. Part of the SCAI initiative is to create best practice documents to leverage successful implementation of these technologies across programs.

The Think Tank noted variability and gaps in formal radiation safety education, particularly for trainees who may face higher exposure early in training. What are the biggest gaps in radiation safety training for trainees and staff, and how can these be addressed?

It is important to note that there is some degree of radiation safety training mandated at the state level. Our trainees are required to complete training at the hospital level and pass a test in order to participate in activities in a fluoroscopy lab. However, this can be variable, and it may be helpful to work to standardize this to ensure a baseline understanding of the principles of radiation safety.

At the Think Tank, we also reviewed data that suggested women were choosing not to pursue an interventional field due to specific radiation risks, particularly during child-bearing years. To that end, ensuring a safe working environment will allow us to continue to recruit the most talented trainees into these fields.

The Think Tank emphasized the need for consistent, multisociety guidance to reduce variability in radiation safety practices and ergonomic standards across institutions and specialties. What steps are critical to build consensus and ensure adoption/implementation across specialties?

I believe that initiatives like the SCAI Think Tank are extremely helpful for building awareness and consistency across different labs. The issues that interventional cardiologists face with respect to radiation safety are identical to those of the electrophysiologists, vascular surgeons, interventional radiologists, or any other operator of staff member performing fluoroscopic

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procedures. This Think Tank was the first to date that was endorsed by nine societies. Additionally, members of industry were available to identify their perspectives on emerging technologies, and administrators shared their experiences and challenges with implementation. There were also a number of success stories, demonstrating that widespread implementation of these technologies is not only feasible but can also be practical and cost-saving as well. But, it all starts with getting everyone in the same room to share their experiences.

For labs that may not have access to the latest equipment, what are realistic first steps to begin implementing ALARA+ principles?

The most important aspect is to maximize the use of currently available technologies and practices. This includes ensuring adequate training of all staff on the fundamental aspects of radiation safety (time, distance, and shielding). Vendors are very amenable to trialing their systems to find one that fits best into an institutional workflow. Ultimately, these are stopgap measures, and there will need to be a reimagining of how we can continue to keep our workforce safe with contemporary technology.

Looking ahead, how do you see ALARA+ shaping the future of cath lab design, team safety, and workforce sustainability?

I think this is the key as we work to design and implement the cath lab of the future. There are a number of very specific challenges that will need to be addressed to ensure that we can continue to perform these life-saving procedures into the future. Today, our cath labs are not as safe as they could be. Our workforce is aging and managing the effects of a lifetime of wearing lead. Because of this, there is a shortage in critical workers needed to perform and support these procedures in the future.

Addressing these challenges will be fundamental to ensuring the sustainability of these fields. Given the lifespan of imaging systems, over the next decade there will be gradual introduction of newer-generation systems that emit less radiation. As these rooms are renovated, it will be a prime opportunity to look at redesigning the rooms and implementing some of the barrier technologies to ensure that operators and staff are as safe as they can be, which means as low and as light as reasonably achievable. ■

1. Salavitabar A, Vora AN, Altschul D, et al. ALARA+: summit on radiation and orthopedic risks in fluoroscopic laboratories. J Soc Cardiovasc Angiogr Interv. 2026;5:104166. doi: 10.1016/j.jscai.2025.104166

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