ORIGINAL ARTICLE

Recommendations From the Blue Ribbon Panel on Fluoroscopy Safety

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Abstract

There are many challenges associated with the safe use of fluoroscopy. These challenges include but are not limited to highly variable regulatory requirements, scope of practice concerns, inconsistent education and training, and lack of staff empowerment. Challenges are further compounded by the increasing use of fluoroscopy across a wide range of medical specialties. To facilitate consensus on how to address the issues, the ACR convened the multidisciplinary Blue Ribbon Panel on Fluoroscopy Safety (BRP-FS), with 32 organizations represented. The goal of the BRP-FS is to establish multi- and interspecialty consensus standards for the safe use of fluoroscopy in health care, including minimum and uniform standards for the education and training of fluoroscopy users that apply across geographic and professional boundaries, for the benefit of all patients and health care providers. Recommendations are made for

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local practices, professional organizations, industry, regulatory agencies, and accreditation bodies. Foundational to the recommendations of the BRP-FS are the personnel training and procedure classification frameworks in National Council on Radiation Protection and Measurement Commentary No. 33.

Key Words: Fluoroscopy, multidisciplinary, radiation protection, safety, training

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INTRODUCTION AND PROCESS

Fluoroscopy is an imaging technique that uses ionizing radiation to obtain real-time images of moving anatomic structures within the body and for image guidance of procedures that are intended to intervene in pathologic processes or deploy various devices. It has been used for diagnostic and interventional purposes in medicine throughout the world for more than a century. Noninvasive and minimally invasive procedures that use fluoroscopy are an integral part of patient care. Their benefits greatly exceed the associated risks when used responsibly by appropriately trained professionals [1]. Fluoroscopy has become an essential imaging tool across a wide variety of specialties in medicine, including but not limited to radiology, cardiology, orthopedics, urology, pain management, general and vascular surgery, gastroenterology, pulmonology, speech pathology, neurology, and neurosurgery. Such a large and diverse group of users leads to unique challenges in ensuring the safe and effective use of fluoroscopy across the health care enterprise. Currently, there is substantial variability in the training requirements and expectations for the use of fluoroscopy among the various end-user groups. Recognizing the challenges associated with such a diverse group of providers using fluoroscopy, the ACR convened a two-day multidiscipline and multiorganization Blue Ribbon Panel on Fluoroscopy Safety (BRP-FS) (Table 1) in Reston, Virginia, on October 2 and 3, 2023, with the goal of arriving at consensus recommendations for improving and standardizing radiation safety practices for the use of fluoroscopy in health care.

The BRP-FS initiative was approved by the Executive Committee of ACR's Board of Chancellors and was co-led by ACR's Commission on Medical Physics and Commis-

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Authors representing an organization that participated in the in-person October 2023 meeting were reimbursed for travel expenses by the organization they were representing. Dustin A. Gress, MS is an employee of the American College of Radiology. M. Mahesh, MS, PhD, is an Associate Editor of *JACR* but had no involvement in the peer review of this article and had no access to information regarding its peer review; full responsibility for the editorial process for this article was delegated to another journal editor. Donald L. Miller, MD is an employee of the U.S. Food and Drug Administration and is Scientific Vice President and Chair, Program Area Committee 4 (Radiation Protection in Medicine), National Council on Radiation Protection and Measurements. Melissa Kirkwood, MD, is a consultant for Gore Medical, received honoraria and research support from Egg Medical, and has a non-commercialized patent on a radiation face shield. Andrew Y. Wang, MD is a consultant for Cook Medical and owns publicly traded stock in GE HealthCare Technologies, Pfizer, and AbbVie. Andrew Kuhls-Gilcrist, PhD, is an employee of Canon Medical Systems USA. Bonnie Martin-Harris, PhD, receives royalties from a licensed educational product they authored. Sarah E. McKenney, PhD received honoraria, is a consultant for, and receives research support from Canon Medical Systems USA. D. Duane Baldwin, MD, has a patent on a technique designed to reduce radiation exposure during PCNL kidney stone surgery and has a patent on a device that can be used for reducing radiation exposure. Alan H. Matsumoto, MD, is the current Chair of the American College of Radiology Board of Chancellors, owns stock in BrightWater Medical and Senzime, and serves on the Data Science Monitoring Board or as an Independent Data reviewer for multiple FDA-approved Clinical Trials. John F. Angle, MD, received research support from Siemens Medical USA, ending in 2023. David B. Weiss, MD, reports a potential relationship with Siemens Medical for their employer to be a demonstration site for a new fluoroscopy device. All other authors authors state that they have no conflict of interest related to the material discussed in this article. All authors are non-partner/non-partnership track/employees.

Table 1. Organizations represented on the Blue Ribbon Panel on Fluoroscopy Safety (acronyms in parentheses)

Organizations Attending October 2023 Meeting
Advanced Medical Technology Association
American Academy of Physician Associates
American Association of Nurse Practitioners
American Association of Physicists in Medicine
American College of Cardiology
American College of Radiology
American Registry of Radiologic Technologists
American Society of Radiologic Technologists
American Society of Regional Anesthesia and Pain Medicine
American Urological Association
Association for Medical Imaging Management
Conference of Radiation Control Program Directors
Image Gently (Image Gently)
Image Wisely (Image Wisely)
National Council on Radiation Protection and Measurements
Radiological Society of North America
Society for Cardiovascular Angiography & Interventions
Society for Pediatric Radiology
Society of Interventional Radiology
The Joint Commission
U.S. Food and Drug Administration
Organizations Added for Consensus After October 2023 Meeting
American Academy of Orthopaedic Surgeons
American Association of Anesthesiologists
American Gastroenterological Association
American Speech-Language-Hearing Association
Health Physics Society
International Pain & Spine Intervention Society
Society for Pediatric Interventional Radiology
Society for Vascular Surgery
Society of Abdominal Radiology
Society of NeuroInterventional Surgery
Society of Radiology Physician Extenders

sion on Interventional and Cardiovascular Imaging and a Board of Chancellors officer. This member leadership worked with ACR staff leadership ("ACR team") identifying stakeholder organizations to be invited to participate in the BRP-FS, with a focus on inclusivity and consensus building. Organizational structure was variable, but most panelists were professional society member-leaders, whether in elected office or well-known domain experts sought out by their professional society to provide representation.

References were solicited, collated, and distributed to panelists before the in-person meeting. The ACR team generated foundational prompts for the panelists to address during the in-person meeting. In order, these were:

1. Identify and rank your top three to five problems or challenges to good and safe use of fluoroscopy.
2. Identify and rank your top three to eight local practices that best facilitate good and safe use of fluoroscopy.
3. Identify the most impactful two to five things the following groups should work on over the next several years: (a) professional organizations, (b) industry, and (c) regulatory agencies.
4. What makes an individual qualified to step on the fluoroscopy pedal?

During the 1.5-day in-person meeting, panelists were randomly assigned into five groups. For each prompt, time was allotted for within-group discussion, and then groups presented their ideas to the panel. Ideas were logged on a projected screen for the panel to view and consider in real time. After all deliberations, consensus ideas were consolidated, debated, and prioritized. The prompts form the framework for how these consensus recommendations are shared herein. Consolidated consensus ideas were placed into an outline, and panelists volunteered to generate first drafts of portions of this consensus paper.

Last, panelists brainstormed on additional specialty societies that should be invited to join the panel to provide recommendations, drafting, and review of the manuscript. After successful outreach by panelists, ACR staff integrated new panelists into the BRP-FS e-mail correspondence structure. It should be noted that not all invited organizations responded, both initially and after the in-person meeting.

A draft manuscript was shared with the full BRP-FS for review and comment; over 130 comments were received. Nearly all comments were easily incorporated; in the few instances in which comment resolution was not straightforward, the ACR team discussed and resolved comments with individual panelists.

Throughout the process, consensus building was top priority.

SCOPE OF CHALLENGES FOR STANDARDIZATION

There are many challenges associated with the safe use of fluoroscopy, including substantial variability in standard operating procedures; state, federal, and international regulations; training; fluoroscopic equipment configuration and controls; radiation units used; dose index monitoring; data collection; preventive and as-needed equipment maintenance; cost of implementation; and performance benchmarking. Optimal use of fluoroscopy may be compromised by time or productivity pressures on providers, lack of funding for monitoring and educational resources, limited institutional radiation physics and

administrative infrastructure, absence of provider interest in and knowledge about the importance of good radiation safety practices, and pressures to manage and care for high patient volumes with limited resources. All are factors that are not conducive to a culture of radiation safety.

A culture of radiation safety in medical imaging environments is a shared commitment among all health care professionals to prioritize and continuously improve safety in the use of ionizing radiation. It encompasses the values, attitudes, behaviors, and practices that ensure radiation is used responsibly to protect patients, staff, and the public from unnecessary radiation exposure. This culture is built on the principles of individual accountability, open communication, continuous learning, and proactive risk management. It encourages staff to speak up about safety concerns, follow best practices, and engage in ongoing education to maintain high standards of care [2,3].

Training and educational paradigms for radiation safety have not kept pace with the rapid growth in fluoroscopy use by many different specialties and provider groups [4-6]. Further, education and training have not been developed with careful consideration of the broad audience of users from different health care backgrounds who have a wide variation in their understanding of radiation physics principles. Optimal and appropriate training levels and training content will vary across disciplines, specialties, or groups of providers based on the types of procedures they perform. It is necessary for education paradigms and standards of safe practice to transcend these differences through appropriate stratification of personnel and procedure types with customized—and simplified when appropriate—fluoroscopy safety education and training.

Regardless of the types of clinical service(s) provided and the types of settings in which it is provided, regulations pertaining to fluoroscopy use in each setting may vary widely depending on state or even municipality rules and regulations. Variable regulatory requirements, especially for operator qualifications, are an obstacle to standardizing the safe use of fluoroscopy.

Although International Electrotechnical Commission (IEC) standards provide standardization for symbols used to control fluoroscopic equipment, the functionality of these controls is not standardized. For example, some manufacturers use the plus symbol (+) for change in field of view to indicate a larger field of view (less magnification), but others use the same symbol to indicate a smaller field of view (more magnification), exactly the opposite functionality, with image quality and radiation dose consequences. When comparing fluoroscopes among manufacturers, user interfaces and tableside control functionality operate differently and can use controls that vary in shape and location. This creates user confusion and increases difficulty in learning how to safely use different fluoroscopic equipment.

In addition, there are currently no standardized or universally accepted dose index benchmarks, specifically diagnostic reference level, for fluoroscopy procedures, including for pediatric patients who are more radiosensitive than adults. Radiation dose is quantified, reported, or recorded with different quantities and terms for different purposes, including air kerma-area product (P_{KA}), reference point air kerma ($K_{a,r}$)*, absorbed dose, peak skin dose, equivalent dose, and effective dose, among others. Although this is necessary, variation in dose quantification and reporting, including use of different units and nomenclature for the same quantity or the same units for different quantities, creates confusion among fluoroscopy users, especially outside of radiology.

*The FDA calls this dose index ($K_{a,r}$) cumulative air kerma; the IEC calls it reference air kerma, which is used frequently in the literature.

The US FDA and the IEC both currently require that audible alarms on fluoroscopic equipment be triggered by fluoroscopy time (5-min intervals), a legacy practice, rather than a more useful trigger such as a standardized radiation dose index value; the IEC may remove the 5-min fluoroscopy timer requirement in a future standard, but it will be years before manufacturers would need to adopt the changes in new equipment. Some current interventional equipment allows a more useful radiation dose index value alert (eg, configurable threshold values for cumulative $K_{a,r}$), which is far more meaningful; however, the alerts are not all standardized nor configurable.

Finally, it is the consensus opinion of the BRP-FS that fluoroscopy's current safety culture varies significantly across clinical sites and can be improved. BRP-FS believes further investigation should be done to understand the lack of motivation to improve at some sites and the lack of empowerment of practitioners to speak up in favor of better practices. An effective and nonpunitive safety culture for fluoroscopy, in which individuals are encouraged and empowered to raise concerns and advance solutions, is essential. The International Atomic Energy Association (IAEA) published such a framework in 2021 that should be applied broadly in fluoroscopy [3].

The multidisciplinary and multiorganizational BRP-FS convened to discuss these challenges and provide potential solutions. The collective mission of medical societies, organizations, industry, and professionals contributing to this document is clear: to establish multi- and interspecialty consensus standards for the safe use of fluoroscopy in health care, including minimum and uniform standards for the education and training of

Table 2. Basis of radiological risk classification of fluoroscopy procedures

Class	Patient Dose for FGP Performed at the Facility	Tissue Reactions	Likelihood of Stochastic Effects in Patients	Likelihood of Stochastic Effects in Staff	Examples
1	>1% of cases deliver a $K_{a,r} > 3$ Gy; when $K_{a,r}$ is unavailable, >1% of cases exceed a P_{KA} of 300 Gy cm^2	Possible	Low*	Minimal to minor*	Potentially high-dose FGP (eg, FGI) (see Table 3)
2	99% of cases deliver a $K_{a,r} > 0.1$ Gy and <3 Gy; when $K_{a,r}$ is unavailable, 99% of cases deliver a $P_{KA} > 10$ but <300 Gy cm^2	Highly unlikely	Minimal to minor*	Minimal to minor*	General FGP (all FGP not in class 1 or 3) (see Table 3)
3	<1% of cases deliver a $K_{a,r} > 100$ mGy; when $K_{a,r}$ is unavailable, <1% of cases deliver a P_{KA} >10 Gy cm^2; no instances of the FGP exceed 200 mGy or 20 Gy cm^2	None	Negligible†	Minimal†	Very low-dose FGP (see Table 3)

Table adapted and reproduced from National Council on Radiation Protection and Measurement Commentary No. 33 [8] with permission from National Council on Radiation Protection and Measurement. FGI = fluoroscopically guided interventional [procedure(s)]; FGP = fluoroscopically guided procedure(s); $K_{a,r}$ = air kerma at the patient entrance reference point; P_{KA} = air kerma-area product.
*NCRP (2012, 2019, 2020), ICRP (2018), Miller (2020) [5,22-26].
†Storm et al (2006) [27], NCRP (2012, 2019, 2020), ICRP (2010) [5,22,23,28,29].

fluoroscopy users that transcend geographical and professional boundaries, for the benefit of all patients and health care providers. This white paper provides consensus recommendations from the BRP-FS.

RECOMMENDATIONS ON LOCAL PRACTICE OPPORTUNITIES FOR IMPROVEMENT

Staffing

Health systems, hospitals, and clinics in which fluoroscopy is used must ensure staffing is sufficient to fulfill clinical needs, so patient examinations are completed safely in a timely manner. Overworked and overwhelmed personnel are more likely to unintentionally compromise even the most reliable fluoroscopy safety programs, potentially risking the safety of patients and personnel. Staff should include individuals qualified to train operators and ensure compliance with regulations, policies, and procedures.

Training

Training of operators and staff in radiation use is essential to minimize risks for operators, staff, and patients [1,7,8]. Although certain states mandate specific training requirements for operators, the BRP-FS recommends that individual facilities in which fluoroscopy is used establish their own educational and training programs, tailored to each person's role in the fluoroscopy environment [8-10]. The process for granting privileges for the operation of fluoroscopic equipment or supervision of fluoroscopy should include requirements for initial and recurrent training in the safe use of fluoroscopy. Initial training should occur during onboarding and recurrent training should occur at regular intervals to maintain competency in the safe use of fluoroscopic equipment [8]. The BRP-FS recommends following the personnel training group stratification provided in Commentary No. 33 from the National Council on Radiation Protection and Measurement (NCRP), based on procedure classes shown in Tables 2 and 3 [8]. In general: Class 1 procedures are potentially higher-dose (eg, fluoroscopically guided interventional) procedures in which the combination of fluoroscopy equipment and procedure complexity makes tissue reactions possible in a small percentage of cases, so more extensive radiation protection knowledge is essential; class 2 procedures are diagnostic and simple bedside imaging, in which doses are typically minimal and tissue reactions are highly unlikely, as well as procedures that result in similar radiation doses; and class 3 procedures are very low dose, typically performed using a mini C-arm, in which doses are never high enough to cause tissue reactions. Detailed procedure classification criteria are shown in Table 2. A summary of NCRP Commentary No. 33 is available [11].

The BRP-FS recommends following the content outlines for initial and recurrent training for each training group in Appendices A through F of NCRP Commentary No. 33—including that all operators using fluoroscopy on infants or children are trained to at least group B—and that recurrent training must occur at least every 2 years. Annual recurrent training may be appropriate for personnel who often work with pediatric or pregnant patients. Didactic

Table 3. Examples of fluoroscopy procedures by class

Examples of Class 1 Procedures (Tissue Reactions Possible in a Small Percentage of Cases)
Ablation procedures
Angioplasty
Percutaneous biliary procedures other than tube maintenance*
Biventricular pacing implants
Complex structural heart disease treatment
Congenital heart disease treatment
Embolization
Radioembolization and chemoembolization
Percutaneous coronary interventions
Stroke therapy
Thrombolysis
Transjugular intrahepatic portosystemic shunt creation and maintenance
Vascular recanalization
Vascular stent placement
Examples of Class 2 Procedures (Tissue Reactions Highly Unlikely)
Diagnostic fluoroscopy (eg, gastrointestinal barium examinations, pacing lead checks)
Vascular access procedures such as tunneled line placement
Orthopedic procedures other than those meeting the criteria for class 3 procedures
Typical "simple" bedside procedures (eg, nasogastric or feeding tube placement, central line placement)†
Fluoroscopy for brachytherapy procedures
Interventional endoscopy (eg, endoscopic retrograde cholangiopancreatography [ERCP], interventional endoscopic ultrasound [EUS], luminal dilation/stent placement)†
Class 3 procedures performed on portions of the body other than the extremities (eg, modified barium swallow)†,‡
Class 3 procedures performed on infants or children‡
All other FGP performed in the facility that are not assigned to either class 1 or class 3
Examples of Class 3 Procedures (Doses Too Low for Tissue Reactions)
Orthopedic procedures performed with mini C-arm fluoroscopes on the extremities
Simple, nontunneled line placement procedures
Pain management or foreign body localization in extremities§
Any other FGP at the facility in which <1 % of cases deliver a $K_{a,r}$ exceeding 100 mGy or a P_{KA} of 10 Gy cm^2, and in no instance does the FGP exceed a $K_{a,r}$ of 200 mGy or a P_{KA} 20 Gy cm^2

Table adapted and reproduced from NCRP Commentary No. 33 [8] with permission from NCRP with minor edits. Class 3 procedures performed on portions of the body other than the extremities or when performed on infants or children are considered class 2. FGP = fluoroscopically guided procedure(s); $K_{a,r}$ = air kerma at the patient entrance reference point; P_{KA} = air kerma-area product.

*Example originally written "Biliary procedures other than tube maintenance."

†Parenthetical(s) not in original table.

‡Items combined in original table, separated here for clarity.

§Example(s) not in original table.

training may be delivered in various formats, such as in person or in virtual sessions, formal live or recorded lectures, or a combination of these methods [8,12]. Resources like the RSNA-American Association of Physicists in Medicine physics modules offer comprehensive online learning [13]. Formal assessment of operators' didactic competence and equipment understanding, via examinations or other methods, is crucial and should include questions related to the impact of equipment settings on patient and operator radiation exposure and image quality. Additional training framework recommendations are available throughout NCRP Commentary No. 33, including the option for individuals to "test out" of otherwise required training by demonstrating proficiency on a written, online, or other test, and that class 3 procedures performed on infants or children are considered class 2.

Advanced hands-on training should include practical and in-person instruction with the fluoroscopy equipment being used clinically. If a facility has multiple fluoroscopes of different models or manufacturers, training must occur for each device an operator may use. Similar training should occur for each specific make and model. Hands-on training must ensure that users and operators of the equipment understand the significance of all controls that affect radiation exposure and image quality. When physicians and other providers conduct class 2 and 3

procedures at multiple hospitals or facilities, it may not be practicable for them to receive in-person instruction on every fluoroscope model they use. In these cases, onsite radiologic technologists credentialed by the American Registry of Radiologic Technologists who have been trained on the equipment should operate the fluoroscope, if possible.

When a new fluoroscopy system is installed, it should undergo acceptance testing by a medical physicist. After acceptance testing, initial clinical applications training by manufacturers' representatives should not only teach how the system is controlled and operated but also highlight safety features and modes that can be used to optimize clinical protocols for image quality while minimizing radiation dose. Periodically investing in additional manufacturer-led hands-on training might be highly beneficial. All stakeholders should work together to ensure the system is appropriately configured to perform the required clinical tasks with a radiation output rate that delivers adequate image quality for the required tasks. This latter process is often referred to as "commissioning" of the fluoroscopic system.

A challenge in local training implementation is the preconceived notion that some specialties or personnel may be exempt from initial or recurrent training. It is the consensus opinion of this BRP-FS that there should be no such exemptions, though the option to test out of most didactic retraining should be available. The BRP-FS also recognizes the challenges associated with local implementation of fluoroscopy training in facilities in rural communities or with lower procedure volumes and in different countries and that creative approaches may be required to achieve the desired safety environment.

Protective Equipment

Availability of personnel protective equipment in each fluoroscopy suite is mandatory. Protective garments must be available for different body types and provide proper fit and coverage. A radiation safety champion should be appointed to oversee appropriate shielding for staff and operators, including proper fit and coverage of the protective garments. When appropriate and reasonably achievable, ancillary protective equipment such as thyroid shields and eyewear should also be provided.

Clinical Protocols and Dose Optimization

Facilities should establish agreed-upon imaging protocol settings for common clinical procedures, ideally customized to use minimal acceptable dose. Lower-dose protocols should be standard, with higher-dose protocols reserved for exceptional cases.

Intraprocedure Actions

Everyone involved in fluoroscopic procedures is responsible for ensuring patient and staff safety. Promoting a culture of radiation safety enables personnel to identify and fix unsafe practices or alert others who can address the situation. Consistent application of the following steps by operators and staff can greatly enhance the safety culture [1,14,15]:

1. Procedural time-outs should include verification that all staff and operators in the room have appropriate protective shielding.
2. The appropriate imaging protocol should be selected. Imaging protocol settings should be established for common clinical procedures to use the minimal acceptable dose. Lower-dose protocols should be standard, with higher-dose protocols reserved for exceptional cases.
3. Optimized collimation should be used throughout the procedure.
4. A radiation safety champion in the procedure room should provide consistent and structured communication, including notification of the operator when the reference air kerma reaches predefined thresholds. This role does not require additional personnel; someone in the procedure room with appropriate knowledge and training should be designated and empowered as the radiation safety champion.

Practice Quality Improvement Program

A dedicated practice quality improvement (PQI) group comprised of representatives from all relevant stakeholder practitioner types, including at least one medical physicist or medical health physicist, should be established and should hold regular meetings to review initiatives related to the use of fluoroscopy and issues relevant to radiation safety that arise or need addressing. This group should also be tasked with developing the standards for the safe use of fluoroscopy at the institutional, departmental, and fluoroscopic unit levels. Institutional and administrative support are vital for establishing this committee and achieving these objectives. Existing radiation safety committees, departmental quality assurance (QA) committees, or equivalent, may be able to serve as this PQI group, or oversee it, depending on state and local requirements and circumstances.

The PQI group should assess existing safety policies and procedures involving the use of fluoroscopy, routinely review these policies, and establish best practices. Appropriate dose notification levels and substantial radiation dose levels must be determined by the PQI group and implemented for both patients and staff [1]. Clinical procedures should be classified as described in Tables 2 and 3. Staff must be

provided with their occupational dosimetry reports with clear instructions on how to review them and what should be done if there are questions or concerns. The group is encouraged to seek support from fluoroscopy dose management references like Fisher et al (2022), IAEA Safety Standards Series No. SSG-46 and, as an example of a modality-specific reference, Forbes (2023) [16-18]. Updated literature and regulatory requirements should be considered and addressed. Occupational and patient dose index data can be effective PQI tools. PQI group meetings should be focused on shared learning with open discussion of practice data and nonpunitive feedback provided to all personnel.

LONG-TERM RECOMMENDATIONS FOR PROFESSIONAL ORGANIZATIONS, INDUSTRY, AND REGULATORY AND ACCREDITING AGENCIES

Promoting a robust culture of safety for the use of fluoroscopy has become essential due to the expansion in its use and the diverse clinical services and environments in which it is being used. The dynamic nature of emerging fluoroscopic technology and the heightened awareness of patient and staff safety drive the need for professional organizations, certifying bodies, industry, and regulatory and accrediting bodies to collectively champion this culture of radiation safety.

Role of Professional Organizations

Standardized Training and Continuous Learning. Professional organizations should play a pivotal role in establishing standardized training and credentialing with consensus-based continuous learning and recurrent training programs. By creating such programs, organizations can instill a culture of continuous learning and improvement in fluoroscopy safety that is standardized. E-only Appendix A provides a suggested pathway for integrating core fluoroscopy safety principles into existing standard training models.

Training should include broadly applicable core principles of radiation physics and safety combined with content focused on specialty-specific procedures and fluoroscopy equipment as described in the previous section. Consensus-driven standard protocols should be developed and defined with accommodation for patient age and size, to include nomenclature for procedures by specialty, and indications for use of fluoroscopy [19-21]. Emphasis should be placed on earlier career training in radiation safety that is subsequently tested on board examinations.

Resources provided by several professional organizations for safe and effective use of fluoroscopy are as shown in Table 4 in the e-only Appendix A, which can expedite further development of core standardized training materials.

The BRP-FS recommends developing a continuing competency evaluation model for fluoroscopy safety similar to that of the Basic Life Support (BLS) or Advanced Cardiac Life Support training and certification provided by the American Heart Association, with content reviewed and updated regularly. The initial and recurrent training content recommended by NCRP is mostly independent of specialty—categorized instead by procedure class—making standard online training modules feasible. Standard online training would then be supplemented by onsite training by a local expert or team using the facility's fluoroscopy equipment.

Internal and External Advocacy. Professional organizations can facilitate the dissemination of radiation safety information through social media campaigns, conferences, webinars, workshops, and publications. By providing a platform for experts to share their knowledge and experiences, organizations can empower their members with the latest information and best practices in fluoroscopy safety.

Professional organizations should also collaborate with governmental entities, industry stakeholders, and health care institutions to establish and enforce sensible safety regulations, standards, and guidance. By engaging in advocacy, these organizations can contribute to the creation of a regulatory framework that ensures the consistent implementation of safety measures. These relationships with industry should also be leveraged to facilitate standardizing fluoroscopy imaging protocols. To provide uniformity and consistency for end users, the protocols should include nomenclature for examinations by specialty, indication, and patient size within individual health care institutions or enterprises.

As fluoroscopy safety transcends borders, national professional organizations may have the opportunity to collaborate with their international counterparts, such as the IAEA, IEC, International Commission on Radiological Protection, and World Health Organization to develop global standards and best practices. Sharing knowledge and experiences across national borders can enhance safety culture on a global scale.

Professional organizations should:

1. Develop standardized training and educational materials for all operators of fluoroscopic equipment, tiered appropriately in content depth according to the types of procedures performed and fluoroscopy equipment used.
2. Develop additional specialty-focused training materials for operators of fluoroscopic equipment.

3. Develop a standardized, continuing program modeled on the efficient and effective BLS and Advanced Cardiac Life Support programs.
4. Embrace various communication platforms to promote fluoroscopy safety to their membership, including using conference programs to provide fluoroscopy safety education.
5. Initiate public awareness campaign using social media and other appropriate tools to effectively educate personnel, patients, and the general public about the importance of fluoroscopy safety, and benefits and risks of fluoroscopy procedures.
6. Partner to advocate for policy changes that prioritize fluoroscopy safety.
7. Collaborate with industry to facilitate optimized and standardized fluoroscopy imaging protocols within clinical practices.

Role of Industry

Industry should support efforts to minimize the use of continuous and high-level control fluoroscopy modes, if still available on the fluoroscopy equipment, and offer pulsed fluoroscopy protocols with lower pulse rates and lower doses. When special demands may exist, such as the need for a high frame rate in swallow imaging for dysphagia or speech pathology applications, dedicated, standardized, lower-dose protocols should be configured and propagated for these specific use cases. Industry should also support the default use of lower-dose protocols with added filtration and visible collimation to minimize radiation exposure while maintaining image quality, thereby aligning with the ALARA (as low as reasonably achievable) principle. Fluoroscopy equipment manufacturers are required to provide instructions on the basic functions of the fluoroscopy equipment in multiple languages according to IEC standards 60601-2-54 and 60601-2-43, but the materials are not easily accessible, and even when they are available, end users are unlikely to adequately incorporate the information into their user training. Manufacturers' applications staff should highlight the safety and dose-reduction features during hands-on training and provide information regarding approaches to optimizing clinical protocols to minimize radiation use. End users must incorporate this information into new user education, in which it is often lacking. Ideally, manufacturers would partner to minimize variability in user interfaces and adopt voluntary standardized tableside control functions, such as those described in the NEMA XR 24 standard, to reduce confusion about equipment function and facilitate operator and provider focus on patient care.

To reinforce the importance of continuous education, industry organizations should offer, as an optional purchase, periodic hands-on training services both before and after equipment installation, and as a stand-alone service. This approach ensures that health care professionals remain adept at using fluoroscopy technology safely and efficiently. Industry organizations should facilitate the use of optimized and standardized protocols within individual health care institutions or enterprises, collaboratively with professional organizations when possible.

Industry should:

1. Support efforts to minimize use of continuous and high-level control fluoroscopy and offer protocols with lower frame rates and doses.
2. Provide dose-reducing techniques by default on fluoroscopy equipment.
3. Provide easily understood and readily accessible reading materials on basic equipment functions for all customers in multiple languages.
4. Provide hands-on training as a purchasable service, pre- and postinstallation, as well as stand-alone.
5. Collaborate with professional organizations to facilitate optimized and standardized fluoroscopy imaging protocols within clinical practices.

Role of Regulatory and Accreditation Agencies

Accreditation bodies should use data to inform and advance a quality improvement (QI) paradigm, and regulatory bodies should do similarly when statutes permit. This use of data involves moving away from solely assessing individual device performance toward an overall practice QA approach. This would foster opportunities for continuous improvement in fluoroscopy practices. Accreditation and state regulatory bodies should also collect and report data on the number of fluoroscopes in clinical use across the United States and their age. Categorizing fluoroscopes based on practice types could provide valuable insights into the prevalence and distribution of fluoroscopy technology in various health care settings.

A shift in focus toward holistic practice QA should include recording and reporting dose indices, comparing practice data to national benchmarks (eg, diagnostic reference level values), and adjusting imaging techniques for procedure complexity and patient size. This initiative would enhance the precision and standardization of radiation dose documentation, facilitating better-informed decision making and optimizing patient and personnel safety. State regulatory bodies could also explore opportunities to standardize fluoroscopy education requirements as much as

possible, similar to current infection control and BLS requirements. This standardization of education requirements would create a consistent and comprehensive approach to training across states, ensuring that health care professionals receive uniform and rigorous education on the safe use of fluoroscopy equipment.

Collaboration with regulatory and accreditation bodies on a global scale could provide a comprehensive review of fluoroscopy regulatory practices worldwide. Regulatory approaches adopted by different countries would be examined to identify best practices. These global insights could be leveraged to improve regulatory frameworks and international standards for fluoroscopy safety.

Regulatory and accreditation bodies should work to raise awareness of radiation safety and regulatory rules. Through targeted campaigns, these bodies could reach a broad audience, including health care professionals, patients, and the general public, fostering a culture of safety and rule awareness.

Regulatory and accreditation agencies should:

1. Collect and report data on how many fluoroscopes are in clinical use across the United States, including practice type, geographical area, and equipment age.
2. Standardize education requirements at a high level.
3. Use social media to increase radiation safety and rule awareness.
4. Move toward incentivizing dose index recording and reporting, including patient size adjustment.
5. Move toward a data-driven regulatory paradigm focused on QA and QI, and away from individual device performance.
6. Review fluoroscopy regulatory practices around the world to consider what international practices may be helpful.

Role of Certification and Credentialing Bodies

The BRP-FS discussed various credentialing examinations taken by health care professionals. Listed in Table 4 of e-only Appendix A are recommended content modifications related to fluoroscopy safety that should be included on certification or credentialing examinations for anyone who has the potential of operating or supervising the operation of a fluoroscopy unit.

SUMMARY

With expanded use of fluoroscopy in medicine and wide variations in existing training requirements, the ACR convened a multidisciplinary and multi-organizational BRP-FS that arrived at consensus recommendations for improving and standardizing radiation safety practices with the use of fluoroscopy in health care.

Implementing standardized local procedures and actions and aiming for long-term opportunities and best practices through policy can bring about substantial and enduring reductions in patient and staff exposure to unnecessary radiation. These changes will require commitment across all levels of local leadership and should be prioritized as risk management through a culture of safety, especially in facilities in which frequent or high-dose fluoroscopy procedures are performed. Stakeholder entities, including professional organizations, industry, and regulatory and accrediting bodies, have critical roles to play in the advancement and standardization of the safe use of fluoroscopy.

TAKE-HOME POINTS

- Standardized, role-specific fluoroscopy training is required for all operators. The panel recommends mandatory initial and periodic refreshers aligned with the NCRP stratified model, with competency assessment for every provider using fluoroscopy.
- Improving the wide variability in fluoroscopy safety culture requires intentional institutional support, including empowered safety champions, adequate staffing, routine protective-equipment checks, and nonpunitive reporting.
- Inconsistent fluoroscope user interfaces can create operational challenges. The panel recommends more standardized controls, improved onboarding, and hands-on training on each device an operator uses.
- Fluoroscopy practices should use standardized imaging protocols and structured dose management processes, including use of lowest dose defaults, real time dose index thresholds, routine personnel dosimetry review, and oversight by a multidisciplinary quality improvement group.
- Sustained improvement depends on coordinated action among societies, regulators, and industry, with harmonized credentialing standards, continued development of safer and more consistent equipment, and alignment of education and quality requirements.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the authors used Microsoft CoPilot to help draft a succinct and clear

paragraph describing a culture of radiation safety in medical imaging. After using this tool/service, the authors reviewed and edited the content and take full responsibility for the content of the publication. Artificial intelligence was not used anywhere in preparation of the manuscript aside from this four-sentence paragraph

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