WHITE PAPER

Patient Safety and Quality in Medical Imaging: The Radiologic Technologist's Role

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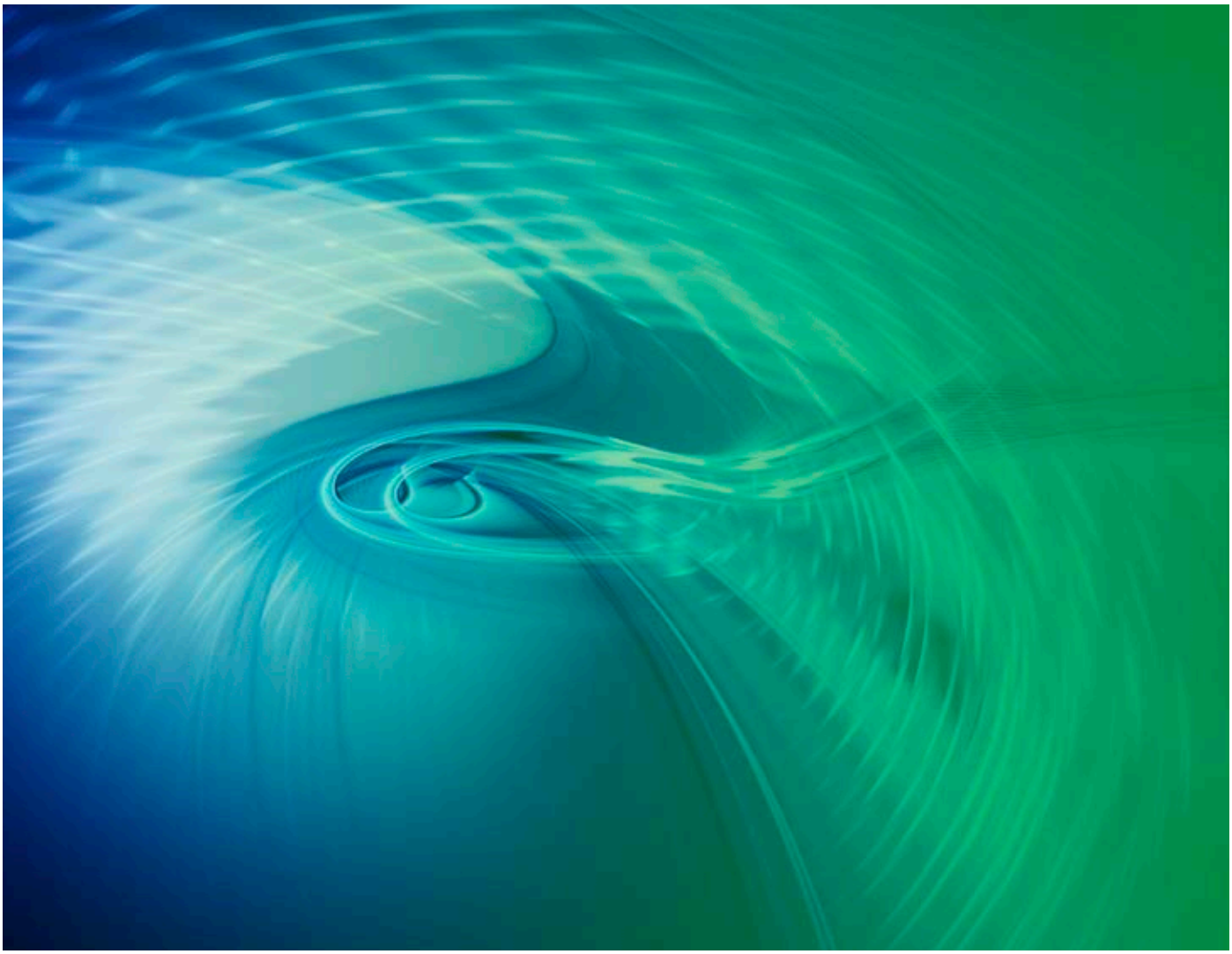
The ASRT Foundation Health Care Industry Advisory Council
Subcommittee on Patient Safety and Quality in Medical Imaging



Published by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3909.

ASRT Foundation

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Radiologic technologists are at the forefront of patient safety and quality. The Code of Ethics of the American Registry of Radiologic Technologists (ARRT), which forms the first part of the ARRT *Standards of Ethics*, includes these four statements:

- The radiologic technologist acts to advance the principal objective of the profession to provide services to humanity with full respect for the dignity of mankind.
- The radiologic technologist assesses situations; exercises care, discretion, and judgment; assumes responsibility for professional decisions; and acts in the best interest of the patient.
- The radiologic technologist uses equipment and accessories, employs techniques and procedures, performs services in accordance with an accepted standard of practice, and demonstrates expertise in minimizing radiation exposure to the patient, self, and other members of the healthcare team.
- The radiologic technologist practices ethical conduct appropriate to the profession and protects the patient's right to quality radiologic technology care.[1]

Physicians, researchers, physicists, engineers and other creative and clinical partners have worked together over the years to continually develop and introduce evolutionary medical imaging equipment. On a regular basis, the medical imaging community announces faster and more accurate features, methods to improve image quality or lower patient exposure, new applications for imaging equipment and new technologies and modalities.

Health care patients benefit from the dedication of budgets and brilliant minds; use of medical imaging can speed and improve diagnosis of a myriad of diseases. Over the past few decades, use of many medical imaging modalities has grown exponentially. For example, 26 million computed tomography (CT) examinations were conducted in the United States in 1998; by 2008, more than 70 million CT examinations were conducted. During the same 10 years, nuclear medicine studies increased from 12 million to nearly 20 million.[2]

The tremendous growth in medical imaging has improved patient care in the United States and around the world. However, some risks and drawbacks have accompanied that growth. Appropriate use and associated costs are of concern to payers and policymakers. Most notably, increased use of diagnostic studies involving ionizing radiation can add to patients' cumulative exposure.[3] Medical imaging contributes to about 15 percent of the average effective dose per capita of people in the United States, and background radiation accounts for 83 percent.[2]

In particular, CT and nuclear medicine have been the focus of concerted efforts to estimate and reduce patient exposure. Use of these imaging modalities has increased and certain CT and nuclear medicine examinations introduce higher doses of radiation than do conventional radiography examinations.[3] Estimates show that CT accounts for about 49 percent of patient

exposure to ionizing radiation from medical imaging, and nuclear medicine examinations account for 26 percent of patient exposure.[4]

The number of radiographic and fluoroscopic studies skyrocketed from 25 million in 1950 to 293 million in 2006.[5] Fluoroscopy is used in a range of diagnostic and therapeutic imaging procedures, and has been the focus of improved technique and monitoring in recent years because of the potential for high skin dose and radiation effects.[6,7] As medical imaging departments transition from an analog to digital environment, there has been a potential for increased patient exposure as radiologic technologists adjust to digital imaging technology.[8] The American Society of Radiologic Technologists (ASRT), American College of Radiology (ACR) and other organizations continue to address this issue in white papers and with educational campaigns, and the vendor community has supported efforts with education and equipment standardization.[9]

Fluoroscopy is one imaging modality used in cardiovascular imaging. Along with radionuclide myocardial perfusion imaging and CT angiography, cardiovascular examinations can introduce high radiation exposures.[10] The total effective dose from contrast-enhanced coronary CT angiography has been estimated to be between 2.1 and 21.4 mSv.[11] In some cardiovascular and interventional examinations, radiologic technologists perform additional patient care duties such as placing peripherally inserted central catheters.

Use of medical imaging that does not involve ionizing radiation, such as ultrasonography and magnetic resonance (MR) imaging, has increased partly in response to concerns regarding cumulative exposure.[2,12] For example, ultrasonography traditionally has been used as an alternative imaging method to modalities that use ionizing radiation for women who are pregnant.[13] Ultrasonography and MR imaging can replace some radiation-based imaging for appropriate cardiovascular indications.[14,15] Safety still is a factor with any medical imaging examination. For example, MR imaging uses high magnetic field strengths and MR technologists typically are responsible for controlling access to the region in which access by non-MR personnel or introduction of ferromagnetic objects or equipment could result in serious injury or death to patients or staff.[16]

According to the U.S. Food and Drug Administration, ultrasonography has been used safely in medical imaging for more than 20 years. Because ultrasonic waves produce effects in the body, such as heating tissues slightly or producing cavitation, U.S. and international organizations have advocated for sensible use of ultrasonography as a diagnostic medical examination, and discouraged its use for nonmedical purposes for fetuses.[17]

The risks vs benefits of mammography continue to be debated, and mammograms must be conducted within the parameters of the Mammography Quality Standards Act.[18] Because this medical imaging modality is regulated, facilities and vendors must meet particular quality specifications and personnel qualification measures. The ACR and the Society of Breast Imaging addressed misinformation regarding thyroid exposure with an April 2011 statement. The thyroid receives no direct radiation exposure from mammography and scattered exposure is minimal, equivalent to about 30 minutes of natural background radiation that average Americans receive.[19]

As researchers and regulatory, advocacy and clinical organizations continue to explore the issue of safety in medical imaging, they consider the delicate balance of effective diagnosis and treatment of disease with the required exposure to radiation or other potential hazards.[10] Among strategies to improve radiation safety are justification, education and optimization of images and technique.[12] The ASRT and its partners recognize the critical role of the radiologic technologist in all aspects of medical imaging patient safety.

The Role of the Radiologic Technologist

It is clear that medical imaging is integral to health care, and scrutiny of imaging examinations is on the minds of policymakers and the general public.[3] To some extent, media reports have produced a degree of fear and anxiety among patients regarding the relationship between medical imaging examinations and cancer.[2] Radiologic technologists often are the health care providers who must deal with the results of media information — or misinformation — and help alleviate patients' concerns.[20]

Radiologic technologists continue to conduct all examinations with concern for patient dose and following ALARA (as low as reasonably achievable) principles

to balance dose and image quality. At times, they do so under the challenges addressed in this paper, such as tighter staffing ratios and declining opportunities for communication with radiologists.

It is critical to health care administrators and medical imaging managers to recognize that the radiologic technologist usually is the first and often the only health care staff member who interacts with patients having medical imaging examinations.[3] The technologist is charged with producing a quality image with the lowest possible patient exposure, under the oversight of the radiologist. In addition, the technologist often is the only health care professional who might recognize that an ordering physician has requested an examination that duplicates one the patient recently has undergone or is questionable in terms of indication or appropriateness.[3]

Because of the technologist's critical role, the ACR has encouraged that radiology practices support regularly scheduled in-service education on radiation safety for technologists and phase in requirements that at least one technologist per site hold advanced certification in the modalities offered by the site.[21]

Certification standards are the purview of the American Registry for Diagnostic Medical Sonography, American Registry of Radiologic Technologists, Cardiovascular Credentialing International and the Nuclear Medicine Technology Certification Board. These certification agencies are governed by independent boards made up of physician and technologist representatives. All of these certification agencies also establish rules and regulations, ethics standards and continuing education requirements for renewing registration.[22-25]

The ASRT is a professional organization with more than 149,000 medical imaging and radiation therapy members. The organization's mission is to advance the medical imaging and radiation therapy profession and to enhance the quality of patient care. The ASRT conducts related research, provides curricula and support to radiologic science educators, develops position statements and practice standards, publishes peer-reviewed journals and offers online courses, Directed Reading articles and other continuing education opportunities to its members.

The ASRT supports certification standards for all technical personnel who perform medical imaging and radiation therapy procedures.[26] The ASRT Practice Standards for Medical Imaging and Radiation Therapy state that technologists should be educationally prepared and clinically competent in all aspects of the work they perform and that technologists should be appropriately certified in all modalities they practice.[27]

Purpose and Scope of Paper

The ASRT Foundation's Health Care Industry Advisory Council (HCIAC) includes representatives of important companies in the medical imaging and radiation oncology industries who work together to advance patient care.[28] Members meet annually, and occasionally form subcommittees to discuss significant issues in the radiologic sciences. The HCIAC Subcommittee on Patient Safety and Quality in Medical Imaging met Nov. 7, 2012, in Albuquerque, N.M.

The ASRT met with the committee of radiologic technologists, many of whom work in the corporate sector of the industry, with the goal of collaboratively improving patient safety and quality in medical imaging. They discussed the current state of medical imaging as well as challenges associated with providing consistently high-quality care and education on equipment and new and emerging technologies. Committee members also discussed the desired state for radiologic technologist workplaces to ensure consistent quality in patient care and to maximize education and understanding of equipment and new technology. This white paper and its recommendations are the direct result of the committee's input. The primary focus of the committee and resulting recommendations is quality and safety in CT, computed radiography/digital radiography, along with all medical imaging specialties.

Current State of Medical Imaging

In an environment of rapid growth and technological advancement, radiologic technologists face a number of challenges when new and emerging technologies are introduced or when equipment upgrades occur. The challenges described in this white paper do not constitute an all-inclusive list of those faced daily by radiologic technologists and medical imaging department managers, but address many of the issues that affect the technologist's ability to continue to provide quality patient care under ALARA principles when adjusting to

new and emerging technologies. In addition, these challenges can interfere with the effectiveness of education by vendors during new or upgraded equipment installations.

Workplace and Staffing

The workplace presents many daily challenges to busy radiologic technologists and medical imaging department managers. One of these challenges is continuing to staff the medical imaging department regardless of budgetary constraints. According to the ASRT Radiology Staffing Survey 2010, more than 70 percent of respondents reported that the number of budgeted full-time equivalents in their medical imaging departments did not increase in 2010.[29] The estimated number of unfilled positions in medical imaging declined significantly (8 percent) between 2003 and 2010 to approximately 2 percent.[29] As budgets and staffing ratios tighten, shifts lengthen and medical imaging departments have less scheduling flexibility. In many small and rural facilities, radiologic technologists often must cross-train and multitask, helping to staff more than one modality.

Studies of nurse staffing have shown that extended shifts can lead to burnout, fatigue and most importantly, can compromise patient safety. Overtime also might be required by some employers. There is also a trend in health care cultures to blend the distinction between voluntary and mandatory overtime, making workers feel as if they must take overtime.[30] When health care workers fail to receive adequate sleep time, they can experience lapses in attention, reduced motivation and diminished ability to solve problems.[31] Vacation time and personal days off are also important.

The culture that demands tight staffing and often long shifts and overtime also makes for difficult scheduling of education. Yet learning a new or emerging technology requires time and attention, and can place additional strain on department scheduling.[32] Radiologic technologists often find it difficult to find personal time for continuing education endeavors, and managers cannot adequately free up schedules for applications training when vendors install new or upgraded equipment.

Education on use of new technology has been cited as a factor that can contribute to eliminating avoidable patient radiation exposure,[33] yet vendors observe that department workflows prevent radiologic technologists from fully attending applications training. This is a workplace and cultural issue that is problematic in medical imaging departments and health care in general. A survey regarding barriers to new technology adoption revealed that finding time necessary to train staff was the second largest barrier to successful adoption, topped only by cost.[34]

An advanced user model (also called a "super user") has been shown to alleviate some of the time constraints. In addition, social persuasion can help people in the workplace learn by observing others' performance and through verbal persuasion.[35] In other words, effective advanced users can train and encourage adoption through modeling ongoing proper use of equipment, answering questions and providing positive reinforcement.

Communication between radiologists and radiologic technologists is an additional workplace issue that can affect image quality and patient exposure, along with the background knowledge technologists need to prepare for new technologies. The ability of technologists to alert radiologists about issues such as multiple examinations on patients and to receive constructive feedback on image quality and exposure from radiologists depends on effective communication. However, technologists have reported that as use of technology has increased, traditional technologist-radiologist communication has decreased. What little interaction that takes place in many busy medical imaging departments and large practices now occurs through electronic notes that accompany digital images transmitted through a network to the physician interpretation room.

Studies have shown that implementation of picture archiving and communication systems (PACS), electronic health records (EHR) and digital imaging shorten turnaround times and increase medical imaging department volume without a subsequent staffing increase.[36] Although use of information technology can help prevent errors and adverse events and help providers track events that occur,[37] the advantages afforded by technology have changed workflow and workplace dynamics in radiology. Technologists no longer enter reading areas to hang radiographs for physicians and potentially discuss technical aspects of the studies in real time. Radiologic technologists often must rely on interpretation of infrequent notes from radiologists, input from their managers or their own

initiative for education regarding image quality and exposure improvement.

Technology Gaps

The importance of information technology to health care cannot be overlooked. Congress appropriated more than $20 billion for health information technology within a 2009 economic stimulus package, and electronic health records are a national priority.[38] Medical imaging depends entirely on technology, perhaps more than any medical specialty.[39] The technological convergence of clinical equipment and computers has occurred rapidly and become ubiquitous in all medical imaging modalities. The advances have occurred so rapidly that many clinicians in the workplace still are uncomfortable with computers.[37] A lack of computer literacy affects perceptions of self-efficacy and expectations of outcome regarding use of or training in new technologies involving health information technology. When a learner believes that he or she can execute the necessary skill or behavior, outcomes from the learning experience generally are better.[35,40]

Technologists are among health care workers who might lack computer skills. Naturally, computer literacy and comfort levels vary. Because skills and comfort levels can vary greatly, there can be wide gaps in the levels of ease technologists have on the job with computer-based job functions. Further, the disparate knowledge complicates education in new technologies and equipment. Applications trainers need to focus on specific equipment functions and features, and should be able to assume that all trainees begin with basic computer skills.

Some of the differences in comfort with technology could be attributed to generation gaps. The Pew Research Center has shown that only 76 percent of those from the older baby boom generation (born between 1946 and 1954) are online, but 95 percent of people from the millennial generation (born between 1977 and 1992) say that they are active online.[41] In a recent study of technology ownership, those aged 19 to 29 owned more cell phones and laptop computers than people from any other age group. People aged 50 and older consistently owned the fewest cell phones, desktop and laptop computers, e-readers and tablets than those younger than aged 50.[42]

Although assigning consistently lower computer literacy and comfort levels strictly according to age or generation could be considered stereotyping, vendors and radiologic technologists have observed some gaps between the skills and comfort levels of recent graduates and technologists who have been in practice for many years. By 2015, the age of radiologic technologists in the workplace will represent workers from the baby boom, generation X and generation Y demographics more evenly. Regardless of the current or future demographics, there is a lack of appropriate skills assessment and training in information technology skills in the health care setting,[43] including assurance that all radiologic technologists have basic computer literacy that help them learn and feel comfortable with new and emerging clinical technologies.

Technology gaps also can exist in basic knowledge of new or emerging medical imaging modalities. For example, some technologists still lack comfort with understanding the basic principles of imaging with digital radiography, and others might rely too heavily on new digital equipment to correct technique factors that once were the purview of the radiologic technologist.[9] Many technologists must cross-train in CT or cardiovascular interventional for department coverage, but conduct examinations infrequently, which provides less opportunity to become familiar with equipment operation and technique. Equipment manufacturers use different terminology and branding to name similar features. This issue is being addressed in digital radiography through efforts to make exposure indicator terminology consistent among vendors and to develop a uniform response relationship between receptor exposure and exposure indicator.[44]

Ensuring that radiologic technologists have the foundation for any current, upgraded or emerging technology is the responsibility of multiple parties. Although accountability rests primarily with the technologist, managers are responsible for hiring, assigning and promoting staff appropriately to ensure patient safety and high-quality imaging examinations in their respective departments. Radiologists ultimately are responsible for the images they review, and should work with managers and technologists to recognize potential shortcomings and help educate as appropriate. Vendors are responsible for providing thorough

training on new and upgraded equipment with cooperation from managers and staff at the facilities where equipment is installed. The medical imaging community and policymakers are responsible for maintaining a focus on patient safety and high-quality imaging through support of measures that ensure only qualified personnel conduct medical imaging examinations.

Workplace Culture

The rapid technological convergence might have advanced more rapidly than technologists' computer capabilities and faster than medical imaging workplace cultures have adapted. For example, lack of certain skills can affect self-efficacy and the focus health care workers have on continued education. Managers, particularly administrators outside of medical imaging departments, often fail to understand the critical nature of applications training and changes technology can cause in technique and patient exposure factors. Further, medical imaging departments might not use the new tools available to them for reporting and tracking dose and for process improvement.

Even when staff is given time to attend applications training, scheduling does not always afford staff time to attend the entire session uninterrupted, or attendees might not be focused on the training. This could be due to concerns regarding coverage or the self-efficacy factor; learners who have high self-efficacy are more likely to visualize a successful training experience and remain more focused than those who have low self-efficacy. A technologist's self-efficacy can be based on individual skills or knowledge, along with the context and culture in which the training and equipment installation takes place. High self-efficacy can assist in training focus and persistence, and with persistence throughout implementation of a new technology.[35,40]

The culture that can lead to low self-efficacy among radiologic technologists and other health care professionals when adopting new technology begins with planning by administrators and nonradiology managers, and teams charged with capital purchases. When implementing converging technologies, inadequate planning can involve failing to include users in the planning process, the mistaken reliance on new or upgraded equipment to solve inefficiencies that actually result from internal departmental problems and failing to consider best practices.[32]

Poor planning and support that lacks a clear structure can lead to inadequate focus or adoption and failure to adequately schedule radiologic technologists for applications training. In addition, inadequate planning for new technology and equipment installations can complicate workflow and cause inefficiencies throughout the entire process — including potentially purchasing suboptimal equipment or features, creating clerical, clinical or technical inefficiencies, extending length and cost of installation, failing to achieve buy-in and training focus from users and repeated operational problems after installation. Having multiple vendors represented can complicate planning for new technology, installations and education, particularly for a new site.

Important patient care aspects are introduced with medical imaging technology that some physicians and leaders outside medical imaging might not fully understand. Adequately adhering to the principles of ALARA requires the cooperation of referring physicians and a supportive and safety-minded culture. Culture change is possible at local and broader levels; pediatric radiation dose offers an excellent example. When the media and public became actively involved in concerns about childhood radiation, organizations, clinicians, government agencies and representatives of a number of resources worked together to address the issue, educate stakeholders and effect change. Eventually, a culture change occurred that modified medical imaging practice.[45]

Thorough planning and strategizing in a safety-minded culture optimizes the use of tools available for reporting and tracking estimated doses and for process improvement. Most medical imaging equipment provides estimated dose information along with the examination, usually in the digital imaging and communications in medicine (DICOM) header.[8,46] Medical and vendor societies have worked together to begin standardizing digital medical imaging exposure indicators (EIs).[8,21] A standard EI value provides an estimate of incident radiation exposure to the detector for each acquired image.[9]

Regardless of standardization, medical imaging equipment offers a variety of data associated with imaging studies, such as estimated dose, dosimetric quantities, demographics and radiographic technique

information that can be compiled and studied for process improvement. Vendors observe that many of these features of equipment are not used by medical imaging departments to the software's capacity. Yet they could be used as part of carefully planned quality management and continuous improvement programs.

Desired State

The challenges that can affect training in medical imaging, and ultimately image quality or patient exposure, can be overcome by observing best practices regarding workplace, technological and cultural issues. The HCIAC committee discussed desired states for medical imaging departments, administrators and industry in terms of best practices.

Workplace and Staffing

Best practice: Medical imaging departments develop staffing policies and procedures that facilitate safe patient care.

Because extended shifts, burnout and fatigue can compromise patient safety, managers should set realistic expectations for staffing that consider high-quality patient care as a priority. Staffing is particularly important when radiologic technologists are required to perform complicated procedures and in MR imaging, where radiologic technologists are responsible for controlling access to the equipment's magnetic field. Failing to staff adequately can affect patient satisfaction, a critical factor in scores now assigned to providers by the Centers for Medicare and Medicaid Services (CMS), and thus in reimbursement.[47]

These policies should include staffing adequately to free time for training on new and upgraded imaging equipment and education about evolving technologies. A 2008 Joint Commission sentinel event alert that addressed safety issues when implementing health information and converging technologies stated that although the time and attention required to learn new technologies can strain already demanding schedules, hospital leadership should establish a training program for all clinical and operations staff who might use new technology. The alert also recommended that the orientation for new technology occur near the time of implementation and that refresher courses be held.[32]

Best practice: Efforts focus on better facilitating radiologist/radiologic technologist collaboration on care, feedback and quality improvement.

In The Joint Commission's 2011 sentinel event alert regarding radiation risks in medical imaging, communication among clinicians, medical physicists, technologists and staff was cited as one of the contributing factors to avoidable radiation dosing.[33] Traditionally, radiologic technologists have learned from radiologists about improving radiographic technique, and radiologists ultimately are responsible for "mastery of technology and dedication to quality and safety" in their practices.[3] In today's digital imaging environment, collaboration between the technologist and radiologist does not occur as often as it did in the film-screen environment. This lack of interaction has resulted in fewer opportunities for the technologist to learn from radiologists and talk about the quality of their images.

Departments should adopt communication strategies and policies in the new digital environment to allow for and even encourage radiologist oversight, involvement and feedback on image technique, exposure and quality. Radiologic technologists usually have sole medical imaging department contact with patients and are the only professionals who might notice duplicate or inappropriate examinations before they occur. Technologists need radiologist input and cooperation to effectively communicate with patients and a departmental system in place in which they can report concerns regarding ordered examinations or technique questions and exposure issues.

Technology Gaps

Best practice: Medical imaging departments provide effective and efficient applications training for new and upgraded medical imaging equipment.

Regular radiologist communication helps radiologic technologists improve basic and advanced technical skills and guidance for patient exposure and ALARA principles. When new and emerging technologies are introduced, radiologic technologists and radiologists must rely on a number of sources for professional development.

Before new or upgraded equipment is installed, radiologic technologists should have a core knowledge of the basics in the modality. The basics of some modalities have changed considerably since radiologic

technologists completed their educational programs. Certification in a modality provides an excellent foundation, but when certification is not practical, there are other avenues. Though employers should make every effort to ensure that application training is effective, it is up to the individual technologists participating to ensure that they are prepared to learn the new technology. For example, computers and health information technology are ubiquitous in medical imaging, and technologists should ensure that they have basic computer skills before attending applications training for the installation of their department's first digital imaging equipment. Radiologic technologists should follow their standards of practice and continue to enhance the perception of their professionalism by participating in lifelong learning, research and publishing opportunities, and adopting new best practices.

Managers and vendors can assist radiologic technologists in determining some of the specific skills needed before applications training begins. Vendors should provide managers with information regarding basic skills and knowledge trainees should possess so that applications training can focus on the equipment and run more efficiently when all attendees are at similar levels in terms of technical and technological skills. Managers can use this information to provide preassessments of trainees' skills before the applications specialist arrives. Similarly, the vendor can work with the medical imaging department manager to provide information for accurate postassessment, so that managers can ensure that radiologic technologists fully understand how to safely and efficiently operate new and upgraded equipment.

Providing effective and efficient applications training requires a certain degree of cooperation between vendors and managers, but also among medical imaging vendors. Once all vendors accept best practices regarding preassessment and postassessment, for example, managers can expect similar processes and deliverables regardless of the manufacturer involved in the equipment installation and training.

Best practice: Recognize that multivendor environments introduce new layers of complexity and require cooperation among vendors and management.

The variation in vendor-specific features necessitates effective and ongoing applications training for medical imaging equipment. Vendors should make available charts with terminology that is specific to their equipment brands to assist radiologic technologists and radiologists, particularly at sites with equipment in the same modality from multiple vendors. Medical imaging department managers should post these charts in conspicuous and convenient locations to assist staff.

Encouraging vendors across all medical imaging modalities to adopt consistent terminology in a manner similar to efforts to standardize digital radiography exposure indicators should decrease complexity for radiologic technologists. This is particularly true for those who cross-train and perform procedures in several modalities and for traveling radiologic technologists. The ASRT has published a white paper that addresses this issue in more detail for digital radiography, along with recommended best practices.[9]

Workplace Culture

Best practice: Medical imaging departments have quality management processes in place; vendors provide documentation and analysis tools that management uses effectively.

Maintaining a regular quality management program is essential to patient care, ALARA principles and a safety culture. Radiologic technologist practice standards address the role of technologists in assessing and adhering to quality management action plans for materials, processes and regular equipment quality control.

In addition, managers can record technique and exposure information provided by medical imaging equipment manufacturers. By investigating patterns outside the range of appropriate technique or dose, radiologists and managers can address and resolve problems by providing education or through other suitable measures. Management should work with vendors to ensure that dosing and technical information from medical imaging examinations captured by equipment is used as intended.

Information gathered from reports, peer-to-peer communication and education and other quality management processes should support patient care and quality improvement efforts. A safety culture encourages openness, communication and nonpunitive follow-up when appropriate. In a culture that emphasizes safety, there are opportunities for peer-to-peer learning and an importance placed on continuous learning. For this to be

successful, radiologic technologists must be dedicated to lifelong learning and be open to accepting constructive criticism from radiologists, managers and peers.

Best practice: Radiologic technologists are educationally prepared, clinically competent and certified in their respective modalities.

When radiologic technologists are dedicated to lifelong learning and professional development, they maintain appropriate clinical competence for their respective modalities. Although maintaining educational preparation and clinical competence is a personal responsibility and an important component of the technologist's practice standards and ethics, the workplace culture should support technologists' efforts. In addition, radiologic technologists should recognize that their professional self-worth and self-efficacy should be connected more closely to professional development than compensation.

When medical imaging departments require that only technologists certified in, or working toward certification in, a respective modality perform procedures in their departments, they support professionalism. Managers can perform and present to administrators cost-benefit analyses of policies such as continuing education reimbursement to support continued competence and new or maintained certifications. Vendors, managers, radiologists, administrators, radiologic technologists and other stakeholders can advocate for legislation to ensure registered radiologic technologists conduct examinations.

Best practice: Vendors and managers collaboratively develop a detailed training agreement that outlines both parties' expectations before finalizing a medical imaging equipment purchase.

Ensuring that radiologic technologists receive effective and efficient education on new and upgraded medical imaging equipment requires detailing site and vendor expectations well in advance of applications training. Vendor expectations might include core knowledge of trainees, amount of time needed from attendees during training, mix and number of procedures to train on, coordination with ancillary equipment set-up or training, and site acceptance and readiness of equipment. Managers should express their expectations regarding education outcomes, scheduling, cost and follow-up assistance from the vendor.

Vendors and managers should work together to discuss education goals and outline the information needed for managers to perform preassessments and postassessments. Likewise, if the manager determines that an advanced user model is the best solution, the manager and vendor should work together to develop identifying characteristics of advanced users and how the user will support the vendor and ongoing education at the site. By identifying advanced users in medical imaging departments whose schedules can be made free for complete applications training, managers can have on-site champions to follow up with staff and contribute to improved learning and operational outcomes. A HCIAC subcommittee on the Definition of the Advanced User in Applications Training developed an advanced user definition in June 2012 to assist managers in identifying advanced users and developing expectations for their assistance in training.

In short, it is critical that the training agreement be carefully planned in as much detail as possible and that appropriate vendor and facility personnel have input to ensure an effective and efficient applications training and successful long-term integration of the new technology into the medical imaging workplace.

Conclusion

Patients now have more information than ever and are empowered to understand the importance of safety and dose when undergoing medical imaging procedures. Radiologic technologists are poised to educate and protect patients. Collaboration of medical imaging stakeholders to support radiologic technologists' education and efforts and to promote a culture of safety and lifelong learning can effect change in medical imaging.

In the busy, budget-driven environment of health care, training time and attention often are sacrificed, yet training is critical to successfully implementing new and emerging technologies.[35] Quick fixes and workarounds are counterproductive, costing more in the long run and compromising safety.[32] Placing a priority on setting expectations for applications training, collaboration among vendors and managers and training appropriately can help ensure effective and safe implementation of new and emerging technologies. Emphasizing a communicative and safe culture in

medical imaging departments supports effective education, along with improving self-efficacy of radiologic technologists and helping them to maintain clinical competence and certification.

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Appendix A

Summary of Best Practice Recommendations

Workplace and Staffing Current State/Challenges:

- Tight staffing ratios, long shifts and overtime lead to high stress and minimize time for learning new technologies and applications.
- Managers have difficulty scheduling adequate time for education about new and upgraded equipment installations.
- There is decreased personal interaction between radiologists and radiologic technologists, largely because of technological advancements.

Workplace and Staffing Desired State/ Best Practices:

- Medical imaging departments develop staffing policies and procedures that facilitate safe patient care.
- Efforts focus on better facilitating radiologist/ radiologic technologist collaboration on care, feedback and quality improvement.

Technology Gaps Current State/Challenges:

- Gaps are evident in computer literacy, understanding basic principles of imaging with digital equipment and comfort levels with technology among radiologic technologists.
- Equipment manufacturers use different terminology and branding to name similar features, causing further confusion with new and existing technologies.
- Ensuring patient safety and image quality requires accountability of multiple and varied parties, particularly radiologic technologists.

Technology Gaps Desired State/Best Practices:

- Medical imaging departments provide effective and efficient applications training for new and upgraded medical imaging equipment.
- There is recognition that multivendor environments introduce new layers of complexity requiring cooperation among vendors and management.

Workplace Culture Current State/Challenges:

- Managers and administrators often fail to understand the critical nature of medical imaging concepts and applications training.
- Inadequate planning and support for new and upgraded technologies can complicate workflow, cause problems with or failure of applications training and contribute to low radiologic technologist self-efficacy.
- Low self-efficacy among radiologic technologists can limit effectiveness of applications training preparation and completion.
- Medical imaging equipment features that help reduce dose or improved quality and processes often are not used to their capacity in medical imaging departments.

Workplace Culture Desired State/Best Practices:

- Medical imaging departments have quality management processes in place; vendors provide documentation and analysis tools that management uses effectively.
- Radiologic technologists are educationally prepared, clinically competent and certified in their respective modalities.
- Vendors and managers collaboratively develop a detailed training agreement that outlines both parties' expectations before finalizing a medical imaging equipment purchase.

Appendix B

The ASRT Foundation Health Care Industry Advisory Council Subcommittee on Patient Safety and Quality in Medical Imaging Members

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