International Journal of Community Medicine and Public Health
Almotairi YA et al. Int J Community Med Public Health. 2024 Sep;11(9):3697-3701
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20242300

Review Article

Strategies for minimizing repeated exposures in diagnostic radiography

Youssef Abdualziz Almotairi*, Turki O. Almutairi, Fahad Homoud Almutairi, Eid Swailem Al Otaibi, Wael Abdarhman Almutairi, Ghadah Fahad Ishaq, Youssef Abdualziz Almotairi

Department of Radiology, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

Received: 28 July 2024
Accepted: 12 August 2024

***Correspondence:**
Dr. Youssef Abdualziz Almotairi,
E-mail: Tofy_444@hotmail.com

ABSTRACT

Advancements in diagnostic radiography have significantly improved medical imaging, yet the associated radiation exposure poses health risks, particularly with repeated examinations. Technological innovations, including the transition from analog to digital radiography, have led to substantial reductions in radiation doses while enhancing image quality. Digital systems, coupled with automatic exposure control (AEC), dynamically adjust radiation levels based on patient size and diagnostic requirements, minimizing unnecessary exposure. Iterative reconstruction algorithms in CT imaging further reduce radiation doses by efficiently processing images and reducing noise. Hardware improvements, such as high-efficiency detectors, capture high-quality images with lower radiation levels, contributing to dose reduction. Standardizing radiographic protocols across healthcare settings ensures consistent practices, reducing variability in radiation doses. Techniques such as beam collimation and appropriate shielding protect surrounding tissues and enhance image quality, while continuous education for technologists maintains proficiency in dose-reduction strategies. Patient education is crucial for minimizing repeated exposures. Informing patients about the risks of ionizing radiation and the importance of adhering to follow-up schedules can reduce unnecessary examinations. Electronic health records (EHRs) facilitate the tracking of cumulative radiation doses, enabling informed decision-making regarding additional imaging studies. Adherence to the ALARA principle (As low as reasonably achievable) in clinical practice ensures that radiation exposure is minimized while achieving diagnostic goals. Special considerations for vulnerable populations, such as children and pregnant women, further enhance safety. Implementing radiation safety measures and maintaining a commitment to ongoing professional development for healthcare providers fosters a culture of safety within radiology departments. By integrating these strategies, healthcare providers can balance the diagnostic benefits of radiography with the imperative to protect patients from unnecessary radiation exposure, ultimately enhancing patient safety and improving diagnostic outcomes. This comprehensive approach ensures that radiographic procedures remain both effective and safe, optimizing patient care in medical imaging.

Keywords: Radiographic exposure, Dose reduction, Digital radiography, Patient education, Radiation safety

INTRODUCTION

Diagnostic radiography is an indispensable tool in modern medical practice, enabling the visualization of internal structures and aiding in the diagnosis of a wide range of conditions. Despite its diagnostic benefits, radiography exposes patients to ionizing radiation, which carries inherent risks, particularly with repeated exposures. Chronic exposure to ionizing radiation has been linked to an increased risk of cancer and other health issues, making it imperative to minimize unnecessary radiation exposure without compromising diagnostic efficacy.[1,2]

One of the primary methods to minimize radiation exposure is through technological innovations. Advances in imaging technology have significantly improved the quality of diagnostic images while reducing the radiation dose. Digital radiography, for instance, has largely replaced conventional film-based systems, offering superior image quality with lower radiation doses.[2] Additionally, the development of dose-reduction software and hardware, such as AEC systems, has further contributed to minimizing radiation exposure. These systems adjust the radiation dose in real-time based on the patient's size and the specific diagnostic requirements, ensuring that the minimum necessary dose is used. Optimizing radiographic techniques and protocols is another crucial strategy for reducing repeated exposures. Standardizing protocols across institutions ensures that best practices are followed consistently, thereby minimizing variations in radiation doses. Techniques such as beam collimation, which restricts the radiation beam to the area of interest, and the use of appropriate shielding can significantly reduce unnecessary radiation to surrounding tissues.[3] Regular training and continuing education for radiologic technologists are essential to maintain proficiency in these techniques and to stay updated with the latest advancements in radiographic practices.

Patient education also plays a vital role in minimizing repeated exposures. Educating patients about the potential risks associated with radiation and the importance of adhering to recommended follow-up schedules can reduce unnecessary repeat examinations. Informed patients are more likely to engage in conversations with their healthcare providers about the necessity and frequency of radiographic procedures, leading to more judicious use of diagnostic imaging.[4] Furthermore, the implementation of EHRs facilitates the tracking of repeated imaging, enabling healthcare providers to make informed decisions about the necessity of additional imaging studies. Minimizing repeated exposures in diagnostic radiography is a multifaceted challenge that requires a combination of technological advancements, optimized radiographic techniques, and patient education. By implementing these strategies, healthcare providers can ensure the safe and effective use of radiography, balancing the benefits of diagnostic imaging with the imperative to protect patients from unnecessary radiation exposure. This review explores strategies to reduce repeated exposures in diagnostic radiography, focusing on technological advancements, optimization of radiographic techniques, and patient education.

REVIEW

The discussion of strategies for minimizing repeated exposures in diagnostic radiography highlights the multifaceted approach required to address this issue effectively. Technological advancements play a critical role, with digital radiography and dose-reduction technologies leading the charge. Digital radiography, which provides superior image quality at lower doses compared to traditional film-based systems, has been a game-changer in reducing patient exposure.[5] Furthermore, the integration of AEC systems ensures that radiation doses are optimized based on patient size and diagnostic needs, significantly lowering the risk of unnecessary exposure. Optimization of radiographic techniques and protocols is equally important. Standardizing protocols across healthcare institutions helps maintain consistency in radiation doses and ensures that best practices are followed. Techniques such as beam collimation, and the use of shielding are essential in protecting surrounding tissues from unnecessary radiation.[6] Continuous training and education for radiologic technologists are crucial in this regard, as they help maintain high standards of practice and incorporate the latest advancements in radiographic technology.

Patient education is another critical component. Educating patients about the risks associated with radiation exposure and the importance of adhering to recommended follow-up schedules can significantly reduce unnecessary repeat examinations. Informed patients are more likely to engage in discussions with their healthcare providers about the necessity and frequency of radiographic procedures, leading to more judicious use of diagnostic imaging. The implementation of EHRs also aids in tracking cumulative radiation doses, enabling healthcare providers to make informed decisions regarding additional imaging studies. Minimizing repeated exposures in diagnostic radiography requires a comprehensive approach that includes technological innovations, optimized radiographic techniques, and patient education. These strategies collectively ensure that the benefits of diagnostic imaging are maximized while protecting patients from the risks associated with unnecessary radiation exposure.

TECHNOLOGICAL INNOVATIONS IN REDUCING RADIOGRAPHIC EXPOSURE

Technological advancements in radiographic imaging have played a pivotal role in reducing patient exposure to ionizing radiation while maintaining, or even improving, diagnostic accuracy. One of the most significant innovations is the transition from analog to digital radiography. Digital radiography systems offer numerous advantages, including improved image quality, faster processing times, and reduced radiation doses. These systems use advanced sensors that are more sensitive to X-rays than traditional film, allowing for the same quality of diagnostic images with lower radiation levels.[7] The immediate availability of digital images also facilitates quicker diagnoses and reduces the need for repeat exposures due to poor image quality.

Another critical technological advancement is the implementation of AEC systems. AEC systems dynamically adjust the radiation dose based on the patient's size, shape, and the specific diagnostic requirements of the examination. This ensures that the minimum necessary dose is used for each procedure, significantly reducing unnecessary radiation exposure. Studies have shown that AEC can reduce radiation doses by up to 50% without compromising image quality.[8] These systems are particularly beneficial in pediatric imaging, where minimizing radiation exposure is crucial due to the increased sensitivity of children to ionizing radiation. The development of iterative reconstruction algorithms in computed tomography (CT) has also been a game-changer in reducing radiation exposure. Traditional filtered back-projection methods used in CT imaging require higher doses of radiation to produce clear images. In contrast, iterative reconstruction algorithms process images more efficiently, allowing for high-quality images at significantly lower doses. These algorithms work by repeatedly refining the image to reduce noise and enhance clarity, thus enabling diagnostic accuracy at lower radiation levels.[9] This innovation has been particularly impactful in high-dose procedures such as CT angiography and cardiac imaging. Moreover, advancements in hardware design, such as the use of high-efficiency detectors, have further contributed to dose reduction. These detectors have improved sensitivity and can capture more information from lower doses of radiation, leading to better image quality with less exposure. Innovations such as flat-panel detectors in digital radiography and direct-conversion detectors in digital mammography are examples of hardware improvements that have enhanced diagnostic capabilities while minimizing patient exposure.

In addition to these technological advancements, the integration of dose-tracking software in radiology departments has provided a means to monitor and manage radiation exposure effectively. These software systems record the dose information for each patient and each procedure, allowing radiologists and technologists to track cumulative doses and identify opportunities for dose reduction. This data-driven approach ensures that radiation safety protocols are followed and that patients receive the lowest possible dose for their diagnostic needs. Technological innovations in digital radiography, AEC, iterative reconstruction algorithms, advanced detectors, and dose-tracking software have significantly reduced radiation exposure in diagnostic imaging. These advancements ensure that patients benefit from the diagnostic capabilities of radiography while minimizing the associated risks of ionizing radiation.

OPTIMIZATION OF RADIOGRAPHIC TECHNIQUES AND PROTOCOLS

Optimizing radiographic techniques and protocols is crucial for reducing unnecessary radiation exposure while ensuring high-quality diagnostic outcomes. This optimization involves the standardization of procedures, implementation of best practices, and continuous training for radiologic technologists. By adhering to these principles, healthcare providers can achieve significant dose reductions without compromising the diagnostic efficacy of radiographic examinations. One of the primary strategies for optimization is the standardization of radiographic protocols. Standardized protocols ensure consistency in imaging practices across different healthcare settings, reducing variability in radiation doses administered to patients. For instance, establishing guidelines for common radiographic procedures, such as chest X-rays or abdominal CT scans, helps technologists apply consistent techniques that minimize exposure.[10] These guidelines often include recommendations on optimal exposure settings, patient positioning, and the use of protective shielding.

Beam collimation is another critical technique in reducing radiation exposure. Collimation involves restricting the X-ray beam to the area of interest, thereby minimizing radiation exposure to surrounding tissues. Proper collimation not only reduces patient dose but also enhances image quality by reducing scatter radiation. Studies have shown that effective collimation can reduce radiation doses by up to 50% in certain procedures.[11] This technique is particularly important in pediatric imaging, where minimizing exposure is paramount due to the increased sensitivity of children to ionizing radiation. The use of appropriate shielding is also vital in optimizing radiographic techniques. Shielding involves placing protective barriers, such as lead aprons or thyroid shields, over parts of the patient's body that are not being imaged. This practice significantly reduces the risk of radiation-induced damage to sensitive organs and tissues. In addition to patient shielding, gonadal shielding is often used to protect reproductive organs, further reducing the potential for genetic damage.[12] Ensuring that technologists are well-versed in the proper application of shielding techniques is essential for maximizing their protective benefits.

Continuous education and training for radiologic technologists play a crucial role in optimizing radiographic practices. Regular training sessions help technologists stay updated with the latest advancements in radiographic technology and techniques. This ongoing education ensures that technologists are proficient in using advanced imaging systems, such as digital radiography and CT scanners, and are aware of the latest dose-reduction strategies. Furthermore, training programs often emphasize the importance of adhering to established protocols and best practices, reinforcing the need for consistency and accuracy in radiographic procedures. Incorporating patient positioning techniques is another effective method for dose optimization. Proper positioning can significantly reduce the need for repeat exposures, which are often caused by poor image quality due to incorrect positioning. Technologists are trained to position patients accurately and to adjust their techniques based on individual patient anatomy and the specific diagnostic requirements of each examination. This precision helps ensure that the initial exposure yields a diagnostically useful image, thereby reducing the likelihood of repeat exposures.

Optimizing radiographic techniques and protocols is essential for minimizing radiation exposure in diagnostic imaging. Standardizing protocols, employing beam collimation and appropriate shielding, and providing continuous education and training for technologists are key strategies in achieving this goal. By implementing these practices, healthcare providers can ensure that radiographic procedures are both safe and effective, maximizing the benefits of diagnostic imaging while protecting patients from unnecessary radiation risks.

PATIENT EDUCATION AND SAFETY MEASURES

Patient education and the implementation of safety measures are fundamental components in minimizing repeated exposures in diagnostic radiography. Educating patients about the risks associated with radiation exposure and promoting adherence to safety protocols can significantly reduce unnecessary radiographic examinations and enhance overall patient safety. Effective patient education begins with clear communication from healthcare providers. Patients should be informed about the potential risks of ionizing radiation and the benefits of diagnostic radiography in a balanced manner. This information empowers patients to make informed decisions about their healthcare and to engage in discussions with their providers about the necessity and frequency of radiographic procedures. Studies have shown that well-informed patients are less likely to request unnecessary repeat examinations, thereby reducing their cumulative radiation exposure.[13] Additionally, educational materials such as brochures, videos, and online resources can be used to supplement verbal communication, ensuring that patients have access to accurate and comprehensible information.

The implementation of EHRs is another crucial aspect of patient safety. EHRs facilitate the tracking of cumulative radiation doses for individual patients, allowing healthcare providers to monitor and manage exposure over time. By maintaining a comprehensive record of all radiographic procedures, EHRs help identify patients who may be at risk of excessive radiation exposure and enable providers to make informed decisions about the necessity of additional imaging studies.[14] This proactive approach ensures that radiation doses are kept within safe limits and that unnecessary repeat examinations are avoided. Incorporating radiation safety measures into routine clinical practice is essential for protecting patients. Healthcare providers should adhere to the principle of ALARA, which emphasizes the importance of minimizing radiation exposure while achieving the necessary diagnostic outcomes. This principle can be applied through various strategies, such as optimizing exposure settings, using protective shielding, and ensuring proper patient positioning. Regular audits and quality assurance programs can help ensure that these safety measures are consistently implemented and that any deviations from established protocols are promptly addressed.[15]

Patient-centered care also involves addressing the specific needs and concerns of vulnerable populations, such as children and pregnant women, who are more sensitive to the effects of ionizing radiation. Special considerations, such as using pediatric-specific exposure settings and providing additional shielding, are necessary to protect these groups. Educating parents and caregivers about the importance of these precautions further enhances compliance and reduces the risk of unnecessary exposure. In addition to educating patients, healthcare providers must stay informed about the latest advancements in radiographic technology and safety protocols. Continuous professional development and training programs ensure that providers are equipped with the knowledge and skills needed to implement best practices in radiation safety. This commitment to ongoing education fosters a culture of safety within radiology departments and reinforces the importance of minimizing radiation exposure. Patient education and the implementation of safety measures are critical for reducing repeated exposures in diagnostic radiography. Effective communication, the use of EHRs, adherence to radiation safety principles, and continuous professional development are key strategies in achieving this goal. By prioritizing patient education and safety, healthcare providers can ensure that radiographic procedures are both effective and safe, minimizing the risks associated with ionizing radiation.

CONCLUSION

Minimizing repeated exposures in diagnostic radiography requires a comprehensive approach that includes technological innovations, optimized techniques, and patient education. Implementing these strategies ensures the safe and effective use of radiographic imaging while protecting patients from unnecessary radiation risks. Prioritizing these measures will enhance patient safety and improve diagnostic outcomes.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Hall E, Brenner D. Cancer risks from diagnostic radiology. Brit J Radiol. 2008;81(965):362-78.
2. Seibert JA. Digital radiography: the bottom line comparison of CR and DR technology. Appl Radiol. 2009;38(5):21-9.
3. Hendee WR, Ritenour ER. Medical imaging physics. John Wiley and Sons. 2003.
4. Fitousi N. Patient dose monitoring systems: a new way of managing patient dose and quality in the radiology department. Physica Medica. 2017;44:212- 21.

5. Bick U, Lenzen H. PACS: the silent revolution. European Radiol. 1999;9:1152-60.
6. McNitt-Gray MF. AAPM/RSNA physics tutorial for residents: topics in CT: radiation dose in CT. Radiographics. 2002;22(6):1541-53.
7. Boone JM, Geraghty EM, Seibert JA, Wootton-Gorges SL. Dose reduction in pediatric CT: a rational approach. Radiology. 2003;228(2):352-60.
8. Mahesh M. AAPM/RSNA physics tutorial for residents: digital mammography: an overview. Radiographics. 2004;24(6):1747-60.
9. Silva AC, Lawder HJ, Hara A, Kujak J, Pavlicek W. Innovations in CT dose reduction strategy: application of the adaptive statistical iterative reconstruction algorithm. Am J Roentgenol. 2010;194(1):191-9.
10. Martin C. Optimisation in general radiography. Biomed Imaging Interv J. 2007;3:e18.
11. Seibert JA, Boone JM. X-ray imaging physics for nuclear medicine technologists. Part 2: X-ray interactions and image formation. J Nuclear Med Technol. 2005;33(1):3-18.
12. Seibert JA. Digital radiography: image quality and radiation dose. Health Physics. 2008;95(5):586-98.
13. Quinn A, Taylor C, Sabharwal T, Sikdar T. Radiation protection awareness in non-radiologists. Brit J Radiol. 1997;70(829):102-6.
14. Rehani M, Frush D. Tracking radiation exposure of patients. The Lancet. 2010;376(9743):754-5.
15. Protection ICoR. Recommendations of the International Commission on Radiological Protection: Vol 1: International Commission on Radiological Protection. 1977.

Cite this article as: Almotairi YA, Almutairi TO, Almutairi FH, Al Otaibi ES, Almutairi WA, Ishaq GF, et al. Strategies for minimizing repeated exposures in diagnostic radiography. Int J Community Med Public Health 2024;11:3697-701.