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Mini-Review

Occupational Radiation Exposure of Surgical Teams: A Mini-Review on Radiation Protection in the Operating Room

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Abstract
Radiation exposure poses a significant occupational hazard to surgical teams working in the operating room (OR), especially with the increasing use of fluoroscopy and interventional radiological procedures. Therefore, exploring the importance of radiation protection and discussing strategies to minimize occupational radiation exposure among surgical teams in this mini-review are crucial. This review will explore the risks associated with radiation exposure, current regulations and guidelines, and effective measures for radiation protection in the OR. Personal protective equipment (PPE), such as lead aprons, thyroid shields, lead gloves, and lead glasses, is essential in mitigating radiation exposure. However, implementing radiation safety protocols, optimizing the positioning of radiation sources, employing suitable shielding materials, and regularly monitoring radiation levels further enhance protection. Education and training programs ensure that surgical teams are knowledgeable about radiation safety, while technological advancements offer innovative tools for reducing direct radiation exposure. By prioritizing radiation protection practices, surgical teams can ensure long-term health and safety in the OR.
Keywords: Operating room, Radiation protection, Fluoroscopy, Ionizing radiation

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Introduction

Occupational radiation exposure is an important concern for surgical teams working in environments where radiation-based procedures, such as fluoroscopy and interventional radiology, are employed (1,2). Surgeons, nurses, anesthesiologists, and other healthcare professionals who participate in these procedures face potential health risks associated with ionizing radiation exposure (3,4). Understanding, mitigating, and managing these risks are crucial to ensuring the well-being of the surgical team members.

Radiation exposure also varies depending on the surgical teams, ranging from an average of 5–50 mrem per case, 10-350 mrem per month, to 2000–3000 mrem per year (5). Occupational radiation exposure in surgical settings occurs primarily during procedures that involve the use of fluoroscopy or intraoperative imaging (6,7). These imaging techniques provide real-time visualization during minimally invasive surgeries, orthopedic interventions, and other complex procedures. Prolonged or excessive exposure to ionizing radiation can pose various health risks to surgical team members, including increased risks of cancer, cataracts, reproductive issues, and genetic abnormalities (8). The cumulative effects of radiation exposure over time should be carefully monitored and taken into consideration.

There is a substantial body of evidence demonstrating the potential for harmful and potentially fatal side effects resulting from exposure to ionizing radiation. As a result, considerable efforts have been directed toward developing a comprehensive understanding of radiation's effects and implementing strategies to prevent such harm (9,10). Various organizations have established guidelines and regulations to ensure the safety of healthcare workers from radiation exposure. The International Commission on Radiological Protection (ICRP) offers standards and recommendations globally, which many countries adopt. In the United States, the National Council on Radiation

Protection and Measurements (NCRP) plays a crucial role in providing guidance specific to occupational radiation protection (11,12).

These guidelines emphasize the optimization of radiation doses, the use of radiation shielding, and the implementation of monitoring and training programs (13). It is important to consider the As Low As Reasonably Achievable principle, which aims to minimize radiation exposure to the lowest achievable levels while considering the medical benefits of the procedure (14,15). Despite these organizations' efforts, it is important to note that there are still ongoing debates and differing perspectives regarding the acceptance and implementation of these recommendations. This discrepancy arises from the fact that the underlying processes and inherent risks associated with radiation exposure continue to be the subjects of ongoing scientific research and investigation.

In other words, while the ICRP and organizations such as the NCRP strive to provide guidance and establish standards for radiation protection, there is still a need to continuously update and refine our understanding of the complexities and risks involved in radiation exposure.

Radiation protection is of utmost importance in the operating room (OR) to safeguard the health and well-being of surgical teams (16,17). With the widespread use of fluoroscopy and other radiation-emitting devices in modern surgical practices, exposure to potentially harmful ionizing radiation has become a significant concern (18).

The use of radiation in the OR has revolutionized surgical procedures, enabling surgeons to perform complex interventions with precision and real-time imaging guidance. However, the benefits of these technologies come with inherent risks, including radiation-induced health issues. Surgical teams, including surgeons, nurses, anesthesiologists, and technologists, are at the forefront of radiation exposure during these procedures, making it crucial to implement robust radiation protection measures.

This review focuses on exploring the importance of radiation protection in the OR and presenting various strategies that can be employed to effectively minimize radiation exposure for surgical teams. In addition, it will discuss the essential role of education and training, technological advancements in radiation protection, optimizing radiation safety protocols, and personal protective equipment (PPE) in mitigating radiation exposure.

Radiation Hazards in the Operating Room

Radiation is an integral part of various medical procedures, including fluoroscopy-guided interventions, interventional radiology, and surgery involving the use of fluoroscopic devices.

The use of fluoroscopy and other imaging techniques in the OR has revolutionized surgical procedures. However, it also exposes healthcare professionals, including surgeons, nurses, and technologists, to ionizing radiation. Prolonged or high-dose exposure can lead to various health risks, including cancer, cataracts, and radiation-induced dermatitis (19,20).

Personal Protective Equipment for Radiation Protection

The use of appropriate PPE is the first line of defense against radiation exposure. PPE for radiation protection includes various specialized clothing and accessories that help shield individuals from harmful radiation exposure (21). The type and level of required PPE depend on the radiation source and the potential hazards involved. Lead aprons, thyroid shields, lead gloves, full-body suits, and lead glasses are essential components of PPE that help minimize radiation exposure to critical organs. Regular inspection, maintenance, and proper storage of PPE are crucial for ensuring their effectiveness (14,22). It is important to note that the selection and use of PPE for radiation protection should be based on a thorough risk assessment conducted by qualified individuals in compliance with applicable regulations and guidelines.

Optimization of Radiation Safety Protocols

Optimizing radiation safety protocols in the OR is crucial to minimizing radiation exposure to both patients and healthcare personnel (13,23). Several essential steps can be taken to improve radiation safety. First, comprehensive training programs can be provided for all healthcare personnel involved in radiation procedures to emphasize the importance of radiation safety, proper use of protective equipment, and adherence to protocols. Second, modern dose monitoring technologies can be utilized to accurately measure and record radiation exposure for both patients and staff. These data can help identify areas for improvement and assess the efficacy of radiation safety protocols. Third, it should be ensured that all staff have access to appropriate PPE. Fourth, healthcare professionals can be encouraged to use alternative imaging modalities or techniques, such as ultrasound or magnetic resonance imaging, whenever possible to minimize unnecessary exposure. Fifth, effective radiation shielding strategies, including lead glass barriers, lead curtains, and radiation shields for nearby personnel, can be implemented within the OR to prevent scatter radiation. Sixth, staff can be trained to position patients and X-ray equipment correctly and use collimators to restrict the X-ray beam to only the relevant anatomical area. Seventh, exposure to the radiation field can be minimized by adhering to the principles of time, distance, and shielding. This includes minimizing time spent in the radiation field, maintaining a safe distance from the radiation source, and implementing additional shielding measures as necessary. Eighth, it should be ensured that all radiation-emitting equipment is regularly inspected, maintained, and calibrated to guarantee accurate and safe operation. Ninth, trends, areas of improvement, and potential risks can be identified by continuously monitoring radiation exposure levels, reviewing protocols, and analyzing data.

Awareness and compliance with safety procedures can be maintained by regularly sharing feedback with staff.

Finally, clear and comprehensive policies and protocols can be established for radiation safety in the OR, and these guidelines can be regularly reviewed and updated based on new research, regulations, and industry best practices. By implementing these strategies, healthcare facilities can optimize radiation safety protocols, minimize radiation exposure, and ensure the well-being of patients and staff (20,24,25).

Education and Training

Knowledge about radiation doses and hazards is important, particularly among physicians who frequently encounter radiological examinations in medical practice (26–28). Therefore, education and training are integral to ensuring that surgical teams are knowledgeable about radiation safety (29). Comprehensive training programs should cover radiation physics, the appropriate use of protective equipment, and strategies for minimizing radiation exposure. Regular refresher courses and updates on current guidelines can help reinforce good radiation safety practices (30).

Furthermore, education and training programs play a pivotal role in promoting radiation safety awareness among surgical teams (13,31). These programs equip healthcare professionals with knowledge about the physics of radiation, the proper use of protective equipment, and effective strategies for reducing radiation exposure. Continuous education and regular updates on current guidelines are essential to ensure that surgical teams stay abreast of the latest advancements in radiation protection (32). In addition, radiation protection is an ongoing process, and staying updated with the latest practices and techniques is essential to ensuring a safe environment in the OR.

Technological Advancements in Radiation Protection

Advancements in technology have facilitated the development of radiation protection tools and techniques (33), including the use of modern imaging systems with dose reduction capabilities, real-time radiation monitoring devices, and robotic systems that reduce the need for direct exposure to radiation during procedures. Exploring and adopting these technological advancements can greatly enhance radiation protection in the OR (34). Overall, technological advancements in radiation protection have significantly enhanced safety measures while reducing potential risks associated with radiation exposure. Continued research and development in this field will likely lead to further improvements in protecting individuals from the harmful effects of radiation.

Radioprotectors

The use of radioprotectors has been proposed as a strategy to mitigate the risks of radiation exposure among medical teams involved in diagnostic and therapeutic procedures (35). Radioprotectors are agents that can reduce the harmful effects of ionizing radiation on living cells (36). Radioprotective agents can be classified into chemical and biological groups consisting of synthetic and natural compounds, respectively. Pre-treatment with these compounds decreased DNA damage while increasing antioxidant levels (37,38).

The administration of radioprotectors is an effective strategy for mitigating the risks of radiation exposure among medical teams involved in diagnostic and therapeutic procedures. By enhancing the overall radiation protection measures in healthcare settings, radioprotectors can help ensure the safety of both medical personnel and patients. Further research is needed to determine the optimal dosing and timing of radioprotective agents for medical teams.

Conclusion

Occupational radiation exposure poses potential health risks to surgical team members involved in procedures utilizing ionizing radiation. Radiation protection in the OR is vital to safeguarding the well-being of surgical teams. By implementing a combination of PPE, radiation safety protocols, education, and training, as well as incorporating technological advancements, we can significantly reduce radiation exposure and ensure the long-term health and safety of healthcare professionals involved in surgical procedures. Safeguarding surgical teams through effective radiation protection practices is a collective responsibility that should be prioritized in every OR environment.

Authors' Contribution

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Competing Interests

The authors state that they have no conflict of interests.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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