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Best practices for radiation safety in radiography departments: Review

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***Abstract*---**This review analyzes radiation exposure risks for healthcare professionals, specifically targeting anesthesia providers and nurses operating in high-radiation settings such as operating rooms and interventional radiology suites. The document outlines sources of radiation exposure, such as mobile radiography, fluoroscopy, and CT scans, emphasizing the cumulative effects of low-dose radiation. Concerns related to radiation exposure in pregnancy are examined, highlighting regulatory guidelines and the necessity of reducing fetal exposure. The review examines factors that affect occupational exposure, distinguishing between modifiable factors, such as procedural techniques and positioning, and non-modifiable factors, including patient size and procedure complexity. The significance of personal dosimeters, such as film badges and optically stimulated luminescent dosimeters (OSLDs), in the monitoring of radiation levels is highlighted, as is the necessity for correct usage and interpretation of dosimeter readings. This paper examines the effects of radiation exposure on nursing and biochemistry, highlighting the necessity for thorough radiation safety training for nurses and the role of biochemists in elucidating cellular responses to radiation and formulating mitigation strategies. The conclusion emphasizes the necessity of proactive monitoring, implementation of effective protective measures, and ongoing education to reduce radiation exposure and protect healthcare workers.

***Keywords*---**Occupational Health, Dosimetry, Radiation Safety, Healthcare Workers, and Radiation Exposure.

1. Introduction

Radiation exposure constitutes a prevalent occupational risk for anesthesia providers in the operating room (OR) and various procedural environments. The rising utilization of mobile radiography, fluoroscopy, and computed tomography (CT) in intraoperative and intraprocedural contexts may result in providers being exposed to low, yet cumulative, doses of radiation (1). A study indicated that overall radiation exposure in anesthesia departments doubled following the regular staffing of an electrophysiology lab, despite relatively low individual exposure levels (2). Given the potential health risks, regular radiation monitoring for anesthesia providers in high-exposure environments, especially those utilizing fluoroscopy for real-time imaging, may be necessary (3).

Radiation safety and protective measures are essential for healthcare providers to reduce exposure to both patients and themselves. A national survey of urology trainees revealed inadequate use of protective equipment, insufficient occupational radiation monitoring, and limited education on radiation safety (4). A survey of physicians indicated that knowledge of radiation safety varied considerably among specialties and training levels, highlighting the necessity for enhanced and standardized training (5). In vascular surgery, formal radiation safety training correlated with improved knowledge, an increased likelihood of monitoring exposure, and the adoption of dose-reduction practices. Research indicates that striation safety programs for orthopedic and radiology residents have significantly decreased radiation exposure for both patients and providers (6).

2. Radiation exposure during pregnancy

Radiation exposure presents specific risks and is governed by strict regulations. The National Council on Radiation Protection and Measurements (NCRP) advises that pregnant healthcare workers should restrict fetal exposure to under 5 mSv throughout the pregnancy or below 0.5 mSv per month (7). The International Commission on Radiological Protection (ICRP) recommends a threshold of less than 1 mSv for the duration of the entire pregnancy. In the United States, employees are not obligated to reveal their pregnancy status; however, should they choose to disclose it, employers are required to offer accommodations to mitigate fetal radiation exposure risks (8).

Studies indicate that radiation exposure below 50 mGy during pregnancy does not elevate the risk of miscarriage, congenital malformations, or childhood cancers when compared to the general population's exposure to background radiation, which is approximately <1 mGy>. Exposure exceeding 500 mGy can result in significant health consequences, including mortality, growth retardation, neurological impairments, and cognitive deficits, especially when such exposure occurs during the first trimester. Despite these thresholds being significantly higher than standard occupational exposures, the risk of radiation-induced childhood malignancy, particularly leukemia, escalates with prenatal doses surpassing 6% of 500 mGy (9).

3. Determinants of Occupational Exposure

Radiation exposure is influenced by both stable and modifiable factors. Non-modifiable factors encompass the complexity of the procedure and patient characteristics, including body size, which may elevate the required imaging dose (10). Practitioners must adhere to the "as low as reasonably achievable" (ALARA) principle by optimizing procedural techniques to limit exposure. This includes reducing fluoroscopy time, minimizing the number of images, and utilizing dose-reduction features available on imaging equipment (11).

In certain procedures, anesthesia providers encounter markedly varying levels of exposure based on their position within the operating room. A study on endovascular aortic repairs indicated that anesthesia providers in specific positions experienced significantly lower doses compared to the scrub nurse, with a 15-fold difference in exposure recorded on the anesthesia machine (12). Pediatric anesthesiologists in cardiac catheterization labs documented exposure levels of 0.2 to 1.8 mSv per month, significantly exceeding those observed in general operating room settings (13). Research has indicated increased exposure in other high-radiation settings, such as the cardiac catheterization suite, emphasizing the necessity for effective monitoring and strategic positioning of providers to reduce radiation exposure (14).

4. Surveillance and Safeguarding

Personal dosimeters are crucial for monitoring radiation exposure in high-risk environments (15). The most commonly used dosimeters include film badges, which contain radiation-sensitive film that distinguishes between different types of radiation using filters. These badges exhibit sensitivity to heat and moisture, rendering alternative options, such as optically stimulated luminescent dosimeters (OSLDs), more suitable in certain environments. OSLDs utilize lithium or calcium fluoride crystals for exposure detection and can be incorporated into rings to measure radiation on the hands, which is essential for providers who closely handle radiation sources (16).

Dosimeters are designated for individual providers and are not to be shared. They are generally worn for a duration of up to three months, with replacement necessary if exposure surpasses 10% of permissible limits. In the course of pregnancy, two dosimeters are utilized: one positioned at the collar level outside a lead apron and another at the waist level beneath the apron to estimate fetal exposure. The fetal dosimeter may overestimate the fetal dose, as it fails to account for the natural attenuation offered by maternal tissues (17).

5. Consequences for Nursing and Biochemistry

In nursing, particularly in interventional radiology, critical care, and operating room environments, comprehension of radiation safety and monitoring is vital for safeguarding staff and ensuring patient safety (18). Nurses in these environments frequently assist physicians during radiation procedures and require training in optimal practices to reduce exposure, including positioning, shielding, and the use of protective equipment. Improved education on radiation protection, specifically designed for nursing roles, can reduce risks and enhance compliance with safety protocols. Nurses engaged in patient education are essential in conveying information regarding radiation safety and the significance of protective measures (19).

Understanding the effects of radiation on cellular structures and DNA is essential for evaluating the short- and long-term consequences of occupational exposure from a biochemical standpoint (20). Exposure to low-level radiation can induce DNA damage, resulting in cellular mutations that may lead to malignancies if the body's repair mechanisms are inadequate. Biochemists play a role in developing strategies for radiation mitigation, including antioxidant therapies and advanced personal protective equipment designed to absorb or deflect radiation. Ongoing research in radiobiology, which investigates cellular responses to low-dose radiation exposure, has the potential to inform occupational safety guidelines and foster innovations in protective technologies (21).

6. Conclusion

Radiation exposure in medical environments presents a complex issue necessitating proactive monitoring, efficient protective measures, and thorough safety education for healthcare professionals, such as anesthesiologists, nurses, and other staff members. Research highlights the necessity for specialized training and the regular utilization of dosimeters to monitor radiation exposure, particularly in high-risk environments such as cardiac catheterization and endovascular suites. Improving safety protocols and optimizing radiation usage can substantially decrease occupational exposure, thereby safeguarding both providers and patients. Advancements in healthcare technology necessitate interdisciplinary collaboration among medical professionals, nursing staff, and biochemists to enhance workplace safety and improve radiation safety standards in healthcare environments.

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أفضل الممارسات لأمان الإشعاع في أقسام الأشعة: مراجعة

الملخص
تحلل هذه المراجعة مخاطر التعرض للإشعاع لمقدمي الرعاية الصحية، مع التركيز بشكل خاص على مقدمي التخدير والممرضين الذين يعملون في بيئات عالية الإشعاع مثل غرف العمليات وأجنحة الأشعة التدخلية. تسلط الوثيقة الضوء على مصادر التعرض للإشعاع، مثل الأشعة السينية المتنقلة، والتصوير بالأشعة السينية القلبية، والفحص بالأشعة المقطعية، مع التأكيد على التأثيرات التراكمية للإشعاع المنخفض الجرعة. تتم مناقشة المخاوف المتعلقة بالتعرض للإشعاع أثناء الحمل، مع تسليط الضوء على الإرشادات التنظيمية وضرورة تقليل التعرض للجنين. تستعرض المراجعة العوامل التي تؤثر على التعرض المهني، التمييز بين العوامل القابلة للتعديل، مثل تقنيات الإجراءات ووضعية المريض، والعوامل غير القابلة للتعديل، بما في ذلك حجم المريض وتعقيد الإجراء. يتم التأكيد على أهمية أجهزة قياس الجرعات الشخصية، مثل شارات الأفلام وكواشف الضوء المحفز بصريًا (OSLDs)، في مراقبة مستويات الإشعاع، وكذلك الحاجة للاستخدام الصحيح وتفسير قراءات أجهزة القياس. تناقش هذه الورقة آثار التعرض للإشعاع على التمريض والكيمياء الحيوية، مع التأكيد على ضرورة توفير تدريب شامل على السلامة الإشعاعية للممرضين ودور الكيميائيين الحيويين في توضيح استجابات الخلايا للإشعاع وصياغة استراتيجيات التخفيف. تؤكد الخاتمة على ضرورة المراقبة الاستباقية، وتنفيذ تدابير وقائية فعالة، والتعليم المستمر لتقليل التعرض للإشعاع وحماية العاملين في مجال الرعاية الصحية.

الكلمات المفتاحية: الصحة المهنية، قياس الجرعات، أمان الإشعاع، العاملون في الرعاية الصحية، والتعرض للإشعاع