The Long-Term Effects of Low-Level X-Ray Radiation on Healthcare Professionals

Minimising doses to healthcare professionals

APC Cardiovascular

Making People Better

Contents

1 The Long-Term Effects of Low-Level X-Ray Radiation on Healthcare Professionals

Long-term exposure to low-level x-ray radiation is a significant concern for healthcare professionals, particularly radiologists, radiographers and other personnel working with diagnostic imaging technologies. Despite strict safety protocols, cumulative exposure over years can pose risks of chronic inflammation and associated diseases, including cardiovascular, metabolic, cognitive and cancerous conditions.

Chronic Inflammation as a Mediator

Prolonged exposure to low-dose ionising radiation (LDIR), such as x-rays, has been linked to persistent low-grade inflammation. Radiation-induced oxidative stress generates reactive oxygen species (ROS), leading to DNA damage, cellular senescence and the activation of pro-inflammatory pathways, such as nuclear factor-kappa B (NF-kB). Over time, this chronic inflammatory state can damage tissues and disrupt homeostasis, creating a foundation for various diseases.

Source:

Pubmed Central[1]

Cardiovascular Disease

Evidence suggests that chronic inflammation induced by low-level radiation exposure can accelerate atherosclerosis, a key factor in cardiovascular disease. Radiation can impair endothelial function and promote the deposition of lipids and immune cells in arterial walls, contributing to plaque formation. Over decades, these processes increase the risk of ischaemic heart disease, myocardial infarction and stroke.

Source:

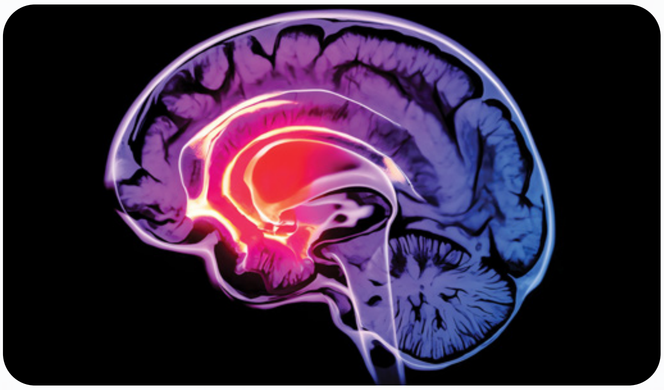
DCEG[2]

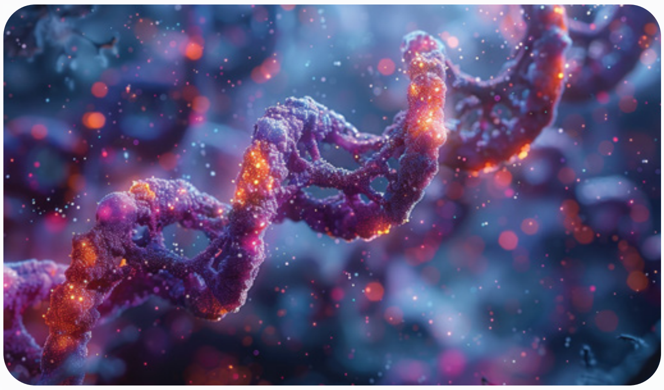
Metabolic Dysfunction

Exposure to LDIR has also been implicated in metabolic disorders, including insulin resistance and Type 2 diabetes. Radiation-induced inflammation interferes with normal metabolic signalling pathways, including those involving adipocytes and pancreatic beta cells. This disruption can contribute to systemic metabolic imbalance, weight gain and other risk factors for metabolic syndrome.

Source:

Exploration Pub[3]





Cognitive Impairment

Chronic exposure to low-level radiation can adversely affect brain function. Persistent inflammation in the central nervous system (CNS) is linked to neurodegeneration, potentially contributing to conditions such as Alzheimer's disease and other cognitive impairments. Studies indicate that radiation can disrupt the blood-brain barrier, promote microglial activation and exacerbate neuronal damage, particularly with long-term exposure.

Source:

Nature[4]

Cancer Risk

The carcinogenic effects of ionising radiation are well documented. Even low-level exposure, when sustained over years, can lead to an accumulation of DNA mutations and chromosomal aberrations. Radiation-induced chronic inflammation creates a pro-carcinogenic environment by impairing DNA repair mechanisms and promoting cellular proliferation. Healthcare professionals exposed to x-rays are at increased risk of haematologic cancers, such as leukaemia, as well as solid tumours, including breast and thyroid cancers.

Source:

JACC[5]

Conclusion

While modern protective measures have significantly reduced radiation exposure in healthcare settings, the cumulative effects of low-level x-ray radiation over a lifetime remain a concern. Chronic inflammation is a central mechanism linking radiation exposure to a spectrum of diseases, including cardiovascular, metabolic, cognitive and cancerous conditions. Continued research and enhanced safety protocols are essential, to minimise risks and protect the health of healthcare professionals.

2 Risk Mitigation

To mitigate the risks of long-term exposure to low-level x-ray radiation and its associated health impacts, healthcare professionals should adopt a combination of personal, institutional and technological strategies. **The five best methods are described below.**

1. Adherence to ALARA (As Low As Reasonably Achievable) Principles

What it involves	Implementation
Minimising radiation exposure by optimising work practices, reducing unnecessary exposure and using the lowest radiation dose necessary for diagnostic imaging.	• Limit time spent near radiation sources. • Maximise distance from radiation-emitting equipment. • Use proper shielding materials, such as lead or lead equivalent aprons, thyroid collars, glasses, gloves and barriers.

2. Use of Advanced Imaging Technologies

What it involves	Implementation
Upgrading to modern imaging systems with lower radiation output and improved efficiency.	• Use digital x-ray systems, which typically emit lower doses than analogue systems. • Invest in dose-reduction software that automatically adjusts radiation levels to patient size and diagnostic requirements.

3. Personal Dosimetry and Monitoring

What it involves	Implementation
Monitoring individual exposure levels through personal dosimeters.	• Regularly wear dosimeters to measure cumulative radiation exposure. • Ensure data is reviewed periodically and implement corrective measures if exposure approaches safety thresholds. • Employers should maintain a robust radiation safety programme that tracks and analyses dosimetry data.

4. Comprehensive Training and Education

What it involves	Implementation
Equipping healthcare professionals with knowledge of radiation safety protocols and techniques.	• Mandatory radiation safety training during onboarding and periodic refresher courses. • Educate staff on proper use of protective equipment, safety protocols and dose reduction strategies.

5. Implementation of Robust Institutional Protocols

What it involves	Implementation
Establishing strict guidelines and systems to prioritise radiation safety.	• Enforce scheduling protocols to limit individual exposure over time (e.g. rotating staff to reduce exposure). • Conduct routine safety audits of radiation equipment and practices. • Install protective barriers and ensure the use of dedicated radiation-free zones within imaging departments.

Additional Considerations

Healthy Lifestyle Choices
Encourage healthcare workers to adopt anti-inflammatory diets, regular exercise and stress management practices to counteract potential long-term health effects.

Periodic Health Screenings
Provide regular medical check-ups for early detection of radiation-related conditions, such as cancer or cardiovascular abnormalities.

By combining these strategies, healthcare institutions and professionals can significantly reduce radiation risks and protect long-term health while maintaining high standards of patient care.

3 Benefits and Risks of Using Barriers that Attenuate X-Rays

Barriers that attenuate x-rays, such as lead walls, shields or curtains, play a critical role in minimising radiation exposure for healthcare professionals and patients. These barriers work by absorbing or scattering x-ray photons, reducing the dose of radiation that passes through to individuals in the surrounding environment.

Roles of Barriers in Mitigating Risks

Absorption of Radiation
Barriers made from high atomic-number materials, like lead or lead-equivalent composites, absorb x-ray photons, significantly reducing radiation exposure.

Protection for Non-Target Individuals
Barriers shield areas outside the direct path of the x-ray beam, protecting staff and patients who are not the focus of the imaging procedure.

Compliance with Regulatory Standards
Proper use of shielding ensures compliance with international and local radiation safety regulations, which require specific attenuation levels in medical facilities.

Reduction of Scatter Radiation
In addition to blocking direct radiation, barriers also reduce exposure to scatter radiation, which can affect individuals even outside the primary beam's path.

Improving Workplace Safety
Strategic placement of barriers (e.g. leaded glass windows) allows healthcare professionals to observe procedures without direct exposure.

Potential Risks and Challenges of Barriers

Inadequate Shielding

- Improperly designed or poorly maintained barriers might fail to provide adequate protection, leading to unintended exposure.
- Barriers may degrade over time (e.g. cracks in lead aprons or walls), reducing their effectiveness.

Increased Weight

- Lead barriers are heavy, and portable shielding (like lead aprons or curtains) can cause ergonomic issues, including musculoskeletal strain for staff using them regularly.

Over-Reliance on Barriers

- Healthcare workers might neglect other safety measures (e.g. proper positioning, reducing time near the source) due to a false sense of security from barriers.

Toxicity Risks During Manufacturing or Disposal

- Lead is toxic, and improper handling during manufacturing, repair or disposal of barriers can pose environmental and health risks.
- Some facilities are transitioning to lead-free shielding materials, but these may be less effective or more expensive.

Conclusion

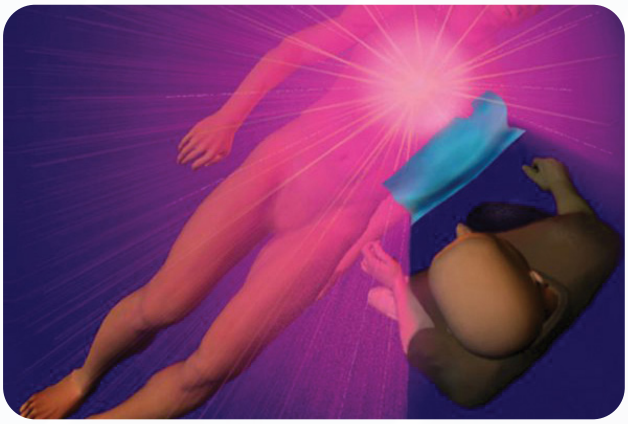
Barriers that attenuate x-rays are indispensable in protecting healthcare workers and patients from radiation exposure. However, they must be properly designed, maintained and supplemented by other radiation safety practices, such as dosimetry monitoring, staff training and adherence to ALARA principles. Regular inspection and consideration of alternative lightweight, non-toxic materials can further optimise their use while minimising associated risks.

4 Use of RADPAD®

How does the product RADPAD® fit into a comprehensive strategy to reduce doses in this context and what is the research?

Incorporating RADPAD® protection drapes into a comprehensive radiation safety strategy can significantly reduce scatter radiation exposure for healthcare professionals during interventional procedures. RADPAD® is a sterile, lead-free and disposable shield designed to attenuate scatter radiation, thereby enhancing existing protective measures.

Role of RADPAD® in Reducing Radiation Exposure



Scatter Radiation Attenuation

Positioned between the radiation source and the operator, RADPAD® drapes absorb scatter radiation, which is a primary source of occupational exposure during fluoroscopy-guided procedures. This attenuation complements other protective equipment, such as lead aprons and shields, by providing an additional layer of defence.

Ease of Integration

RADPAD® drapes are designed for single use and can easily be incorporated into various procedural set-ups without significant workflow disruption. Their lead-free composition also addresses concerns related to the weight and toxicity of traditional lead-based protective devices.

Research Supporting RADPAD® Efficacy

Multiple studies have evaluated the effectiveness of RADPAD® drapes in reducing radiation exposure:

2024

Systematic Review and Meta-Analysis

A comprehensive analysis of six studies involving 892 patients demonstrated that the use of RADPAD® significantly reduced radiation exposure to primary operators in cardiac catheterisation laboratories. The study concluded that RADPAD® drapes should be recommended in all catheterisation laboratories to enhance radiation safety.

Source:

Pubmed Central[6]

2018

Randomised Clinical Trial

Research published in *Circulation: Cardiovascular Interventions* assessed the efficacy of RADPAD® in reducing operator radiation exposure during cardiac procedures. The study found a significant reduction in radiation dose when RADPAD® was utilised compared to conventional safety measures.

Source:

AHA Journals[7]

2018

Clinical Evaluation

A study in the *Indian Heart Journal* evaluated RADPAD® shielding across 65 consecutive percutaneous coronary intervention (PCI) procedures. Results indicated that, RADPAD® significantly reduces radiation exposure to the primary operator during prolonged complex PCI procedures.

Source:

Pubmed Central[8]

Conclusion

Integrating RADPAD® protection drapes into radiation safety protocols offers a proven method of reducing occupational radiation exposure. Supported by clinical research, RADPAD® serves as an effective adjunct to existing protective measures, contributing to a safer working environment for healthcare professionals involved in interventional radiology and cardiology procedures.

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