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A REVIEW OF RADIATION PROTECTION APRON FOR HEALTH FACILITIES: WITH FOCUS ON LEAD APRON

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Abstract

In medical diagnostic and therapeutic procedures, ionizing radiations are commonly used. The major radiations used are the X-rays and Gamma rays. The personnel working in the radiological facilities to carry out these procedures are supposed to be properly shielded from the harmful effects of these radiations. The currently used aprons are made up of Lead which is a heavy metal. Several studies have been documented showing that Lead aprons provide appropriate shielding against ionizing radiation. This is basically due to its chemical property being a heavy metal hence radiopaque. However, Lead apron has its disadvantages. This review is therefore focused on the disadvantages that come with the use of Lead aprons in medical procedures. Several literature reviews have highlighted these disadvantages which include; bulkiness as a result of Lead being a heavy metal, very expensive and therefore difficult for the government to avail to every radiological personnel across the country. Furthermore, it is toxic to the ecosystem due to its chemical nature. The texture of the Lead apron also inconveniences the wearer. These, in turn result into compromise amongst the radiological personnel by not putting them on during these procedures. Thus, exposing their bodies to these ionizing radiations which may cause either deterministic or stochastic effects. In conclusion, this paper suggests the need to investigate an alternative radiation shielding apron that is lighter, cheaper, ecofriendly and convenient to the wearer by using different materials and methods, such as the use of barium which provides a better radiation shielding as Lead.

Keywords: Radiation protection aprons, Health facilities, Lead aprons, Radiation shielding, Bulkiness, Barium

1. Introduction

Ionizing radiations, in particular X-rays and Gamma rays, have become an essential component of diagnostic and therapeutic processes in the field of modern medicine (Soliman, 2023). These potent instruments have transformed healthcare by enabling exact diagnoses and focused therapies (Soliman, 2023). For the committed staff members working in radiological facilities, ionizing radiation's inherent nature poses a serious occupational risk (Najjar, 2023). Utilizing protective equipment, such as radiation protection aprons, is essential to reducing the dangers connected with ionizing radiation exposure (Park & Yang, 2021).

The lead apron is currently the cornerstone of radiation shielding in medical facilities (Bjørkås et al., 2020). These lead-based heavy metal aprons have a long history of being respected as strong radiation shields (Bjørkås et al., 2020). Lead is a great material for radiation shielding because of its special chemical characteristics, particularly its status as a heavy metal and its radiopaque qualities. Lead aprons do, however, have some disadvantages, just like any other technology (Rahmat et al., 2023).

With a laser-like focus on the drawbacks of using lead aprons in medical operations, this paper explores the complex world of radiation protection aprons. These drawbacks have been highlighted by numerous investigations and academic works, highlighting their importance (Bjørkås et al., 2020; Kim, 2022; Zakaly et al., 2022). These negatives include the ungainly bulkiness brought on by lead's inherent weight, the costly cost making it difficult to provide for all radiological staff, the toxicity of lead making it unpleasant to the environment, and the discomfort brought on by the texture of lead aprons for wearers (Al-Makhamreh et al., 2022). Tragically, these restrictions have led to a demoralizing compromise among radiological staff members who, in some situations, choose to perform procedures without wearing their protective equipment (Rabah et al., 2023). They are left vulnerable to the dangerous effects of ionizing radiation, which can have both deterministic and stochastic negative impacts on their health, because they failed to put on protective aprons.

It becomes clearer that a review of radiation shielding options is necessary in light of these difficulties. In order to address the drawbacks of lead aprons, this paper promotes the investigation of substitute materials and techniques. It specifically highlights the need for radiation shielding aprons that are more lightweight, affordable, environmentally friendly, and wearable. Investigating barium-based substitutes, which have the potential to offer better radiation shielding than lead (Kim, 2022), is one such promising path. Through this review, we set out on a quest to investigate the drawbacks of lead aprons and open the door for creative and enhanced radiation protection solutions, eventually ensuring the safety of radiological staff members and the patients they are responsible for treating.

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2. **Bulkiness and Discomfort**

The significant bulkiness of lead apron is one of its main shortcomings when it comes to radiation shielding. This property is a result of lead's fundamental status as a heavy metal. The heavy metal quality of lead makes it a good radiation attenuator, but it also adds a lot to the weight and thickness of lead aprons. These aprons are frequently required to be worn by healthcare professionals for long periods of time during medical operations, which causes discomfort and exhaustion (Al-Makhamreh et al., 2022).

Lead aprons' bulk presents a number of difficulties and discomforts:

2.1 Musculoskeletal Strain: During diagnostic and interventional procedures, healthcare professionals, particularly radiological staff, are sometimes obliged to wear lead aprons for prolonged periods of time (Fakhoury et al., 2019). These aprons' weight can put strain on the musculoskeletal system, resulting in discomfort and perhaps long-term health problems. For instance, radiographers who wear a heavy apron all the time may develop back and shoulder pain.

2.2 Movement Restrictions: The wearer's movement and range of motion may be restricted by the thickness and weight of lead aprons. This constraint may make it difficult to carry out sensitive medical treatments effectively and precisely.

2.3 Heat Accumulation: The bulkiness of lead aprons can also result in heat accumulation, which can be especially uncomfortable in settings where temperature regulation is crucial, such as operating rooms.

2.4 Skin Irritation: Lead aprons' texture can occasionally irritate skin, especially when worn for a lengthy period of time. People with sensitive skin may experience greater discomfort as a result.

2.5 Communication Barriers: The bulkiness of lead aprons may make it difficult for healthcare team members to clearly communicate with one another, thereby impacting coordination and teamwork during medical procedures.

2.6 User Fatigue: The additional physical effort needed to wear and move around in lead aprons can cause user tiredness, which may have an impact on the standard of healthcare delivery.

2.7 Reluctance to Wear: Some medical professionals may be less likely to continuously wear bulky lead aprons due to their discomfort, particularly during operations with comparatively modest radiation exposure concerns. This reluctance increases the chance of radiation exposure and undermines radiation protection.

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2.8 Challenges with Donning and Doffing: Medical treatments may be delayed if lead aprons must be put on and taken off in a laborious manner.

Overall, the bulkiness of lead aprons is a serious disadvantage that affects the safety and comfort of medical workers.

3. Cost Considerations

One of the significant limitations of lead aprons in the area of radiation protection for healthcare facilities is their high price (Engström et al., 2021). Both healthcare organizations and their staff must take into account these cost factors. We look at a number of factors that affect how expensive lead aprons are below:

3.1 Costs of Materials: Due to its remarkable radiation-shielding qualities, lead is a heavy metal that is relatively expensive to obtain and manufacture ((Engström et al., 2021). The entire cost of lead aprons is substantially influenced by the price of the raw material.

3.2 Manufacturing Complexity: Crafting lead aprons involves intricate manufacturing processes to ensure the lead is properly encased and distributed to provide effective radiation protection. These processes can be labor-intensive and add to the overall manufacturing cost.

3.3 Quality Assurance: Ensuring the quality and safety of lead aprons requires rigorous testing and quality assurance protocols. These measures add further costs to the production and distribution of these protective garments.

3.4 Limited Accessibility: Due to their high cost, lead aprons can be financially burdensome for healthcare institutions, especially smaller clinics and facilities with limited budgets. This limitation may result in unequal access to adequate radiation protection among healthcare workers.

3.5 Replacement and Maintenance: Lead aprons may deteriorate or get damaged over time, requiring replacement. Healthcare budgets may be put under stress by the ongoing expense of replacing aprons. Additionally, ongoing costs for maintaining lead aprons, such as routine inspections and cleaning are increased.

3.6 Environmental Impact: Due to lead's toxicity, disposing of lead aprons after they have reached the end of their useful lives may require additional steps and expenses. This adds to the overall environmental and financial burden.

3.7 Financial Restrictions on Healthcare Workers: If healthcare workers are compelled to buy their protective equipment, the high cost of lead aprons may put a strain on their finances.

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3.8 Cost-Benefit Analysis: Healthcare facilities must perform cost-benefit assessments to ascertain whether it is financially feasible to provide lead aprons for all pertinent staff. Because of the high expense, decisions may occasionally be made to give some employees priority over others.

Healthcare facilities frequently struggle to allocate funds for radiation protective equipment due to the high costs of lead aprons. The cost of providing all radiological staff with access to appropriate protective equipment can impede efforts in this direction, perhaps putting some healthcare workers at higher risk of radiation exposure.

4. Toxicity and Environmental Concerns

Although lead aprons are an efficient way to shield against ionizing radiation, there are serious questions about their toxicity and environmental impact. These worries call attention to significant negative effects connected with the usage of lead aprons in healthcare facilities

4.1 Lead Toxicity: Lead is a heavy metal that is notorious for being hazardous to humans (Sarıbal et al., 2023). Lead exposure that is prolonged or excessive can have negative effects on the neurological system, blood, and kidneys (Sarıbal et al., 2023). Healthcare workers who handle, store, or maintain lead aprons run the danger of unintentionally being exposed to lead dust or particles because to the poisonous nature of lead (Sarıbal et al., 2023).

4.2 Environmental Contamination: Lead is also bad for the ecosystem. Lead can leak into the land and water when lead aprons are not disposed of properly, causing environmental risks. The buildup of lead in the environment can have far-reaching effects, including affecting wildlife and ecosystems.

4.3 Regulatory Compliance: The use, disposal, and management of lead-containing items, including lead aprons, are subject to stringent rules and regulations that healthcare facilities must follow (Alyami & Nassef, 2022). The cost and complexity of employing lead aprons are increased as a result of the additional resources and methods needed to comply with these laws.

4.4 Healthcare Worker Safety: It is crucial to safeguard the health and safety of healthcare employees. To prevent lead exposure, precautions must be taken, including careful handling and storage of lead aprons, routine cleaning and repair, and attention to safety procedures.

4.5 Disposal Challenges: When lead aprons reach the end of their useful lives, it is important to dispose of them carefully to avoid contaminating the environment. This could result in higher disposal costs and provide logistical difficulties.

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5. The Need for Alternative Materials and Methods

It is imperative to look for alternate materials and techniques that can provide efficient radiation shielding while resolving the downsides of lead given the considerable issues with lead aprons in radiation protection within healthcare institutions. This necessity results from a number of issues, including worries about cost, toxicity, bulk, and user discomfort. The demand for alternative solutions is fueled by several important factors:

5.1 Reducing Bulkiness: Lead aprons' bulkiness, which results from their heavy metal composition, has been a recurring problem (Al-Makhamreh et al., 2022; Bijanu et al., 2021). Healthcare workers need protective equipment that gives efficient radiation protection without restricting their comfort or movement. Alternative building methods and materials are intended to offer lighter, thinner solutions without sacrificing protection.

5.2 Cost-Effectiveness: Lead is expensive (Engström et al., 2021), and producing lead aprons requires challenging manufacturing procedures (Engström et al., 2021), which has put a strain on healthcare organizations' budgets. It is possible to create radiation protection systems that are more affordable and available with alternative materials and techniques, ensuring that all healthcare workers have access to suitable protection.

5.3 Reducing Toxic Effects: When lead aprons are disposed of inappropriately, they can cause health problems for the environment and healthcare personnel who wear them (Sarıbal et al., 2023). Alternative materials should provide efficient radiation protection without the inherent toxicity of lead, easing worries about human health and the environment.

5.4 Improving User Comfort: Lead aprons can cause user tiredness and discomfort (Al-Makhamreh et al., 2022), which can affect how well healthcare is delivered. Aprons that are made of different materials and feature design innovations are intended to be more comfortable to wear for prolonged periods of time, enabling healthcare personnel to properly carry out their jobs.

5.5 Environmental Considerations: Lead-free alternatives to aprons should adhere to environmentally friendly procedures from production to disposal as healthcare institutions promote sustainability and environmental responsibility.

5.6 Innovation and technological advancements: New avenues for radiation shielding have been made possible by developments in materials science and technology (Kim, 2022). Alternative materials being investigated include bismuth and barium, which give comparable radiation attenuation to lead (König et al., 2023; Rahmat et al., 2023; Zakaly et al., 2022).

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5.7 User acceptability: The successful adoption of alternative radiation protection strategies depends on user acceptability. Healthcare workers must be willing to constantly wear protective equipment, therefore alternatives must be comfortable and functional for them.

5.8 Regulatory Compliance: To safeguard the security of medical personnel and patients, all alternative materials and procedures must abide by legal requirements and radiation protection norms.

Consequently, the drawbacks of lead aprons call for a proactive search for substitute materials and techniques that might provide efficient radiation shielding while minimizing the drawbacks of lead. A crucial first step in enhancing radiation safety in medical institutions is the continual investigation of alternative options, which will ultimately preserve the wellbeing of medical personnel and the caliber of patient treatment. This goal is consistent with how healthcare is changing, where innovation, safety, cost-effectiveness, and environmental responsibility are valued.

6. Conclusions

We have explored the downsides of lead aprons in radiation shielding within healthcare facilities in this thorough assessment, highlighting key issues that have long been acknowledged by both researchers and healthcare workers. The main issues with lead aprons are their mass, expense, toxicity, and discomfort for the user (Al-Makhamreh et al., 2022; Sarıbal et al., 2023). All of these problems highlight the urgent need to investigate new radiation shielding materials and techniques for use in medical facilities.

Due to their outstanding radiation attenuation qualities, lead aprons have formed the foundation of radiation protection (Bjørkås et al., 2020). However, when worn by healthcare professionals during diagnostic and interventional procedures, their cumbersome bulkiness can cause musculoskeletal strain, restricted mobility and pain. The high cost of lead and the difficulties involved in its manufacture make it financially difficult for healthcare organizations to provide all employees with proper radiation protection. Additionally, due to lead's toxicity, users and the environment face health hazards, demanding strict regulatory compliance and safe disposal procedures. Wearers' discomfort increases their reluctance to routinely utilize lead aprons, thereby jeopardizing radiation protection.

There is a growing movement to investigate other radiation protective materials and techniques in order to address these shortcomings. These options try to find a compromise between costeffectiveness, reduced toxicity, improved user comfort and environmental sustainability while providing efficient radiation shielding. Alternatives like bismuth and barium, which give equivalent

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radiation attenuation to lead while being lighter and less hazardous, have emerged as intriguing options (Rahmat et al., 2023; Sarıbal et al., 2023).

Healthcare organizations, researchers and manufacturers are urged to work together to develop novel radiation protection solutions in this quickly changing environment. Healthcare professionals' safety and wellbeing should come first in these solutions. They should also adhere to the values of economy and environmental responsibility. Regulatory organizations are essential in ensuring that these substitutes adhere to the required norms and regulations for radiation protection.

The drawbacks of lead aprons highlight the urgent necessity to embrace innovation and look into different radiation shielding materials and techniques. By doing this, we may improve radiation safety in healthcare facilities, equip medical personnel with comfortable and efficient protective gear and support the development of a more resilient and long-lasting healthcare system that will benefit patients as well as medical personnel.

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