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Development of X-ray Radiation Protective Apron System

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Abstract: The personnel at the cath lab have been wearing lead aprons to shield themselves from the scatter radiation for decades. The weight of all the aprons, however, may cause discomfort, physical and mental stress with the burden and postural disorders. As a result, X-ray Protective Apron system is being developed as a therapeutic protective device to solve the problem of previous protective devices. Interventional specialists who are performing proximity operations during radiological interventional diagnostics and treatments are protected by this System. In present research, providing zero-load protection, the X-ray protective Apron System eliminates weight from the body, preventing bone injury. The ergonomic design allows for easy bend and tightening and allows for flexible use. In medical institutions, lead aprons are used to shield employees and patients from needless x-ray radiation exposure during diagnostic radiology procedures. A lead (or lead equivalent) apron is a protective garment used to shelter the body from dangerous radiation, typically during medical imaging.

Keywords: X-ray Radiation, Cath Lab, Apron Protection System

1. Introduction

A radiation with enough energy to carry off electrons from an atom or molecule is referred to as ionizing radiation. Ionizing radiation causes tissue harm, including cell death, cancer, and cancerous tumors [9]. Deterministic effects are direct health effects of radiation that are dose-dependent with a dosage threshold, such as skin necrosis [3]. Skin burn is a documented consequence of radiation therapy in the Cath Lab. Additionally, there are a number of deterministic consequences that can occur, such as: cataracts and opacities of the lens reduced reproductive capacity and a decrease in white blood cells [2].

As the potential complexity of interventional treatments has grown, the need to limit the radiation dose to operators has grown again [11]. Interventional cardiologists are the professionals most exposed to radiation [1]. In the context of coronary artery disease, peripheral arterial disease (PAD), left atrial appendage occlusion (LAA), and trans catheter aortic valve replacement (TAVR), and chronic complete occlusions (CTOs) procedures are substantially more time-consuming and difficult than standard percutaneous coronary interventions (PCIs) [8]. It is vital that medical personnel wear lead shielding for their safety. Wearing heavy lead aprons has been shown to aggravate interventionalists orthopedic back pain difficulties [15]. Time, distance, and shielding are all vital concepts for protecting yourself from radiation. An alternative solution is the X-Ray protective Apron System. The gantry allows a lead-lined walk-in suit to be supported from above, lifting the weight of lead aprons off the interventionist's chest [19]. It is also able to move seamlessly in all X, Y and Z axis, including vertical [20]. The X-ray protective apron system eliminates the weight load of apron on the personnel’s body. Compared to conventional lead aprons with under table shields or ceiling-mounted shields, X - Ray protective Apron system provides superior operator protection during fluoroscopy [24]. X- Ray protective Apron system allows clinicians freedom of movement, especially during challenging procedures [5]. It is flexible and can be adapted to meet the needs of any room environment.

2. Material and Methods

Radiation shields consist of lead acrylic panels that decrease radiation diffusion, shielding the physician as well as their staff. The X-ray protective Apron system shield is designed to protect interventional doctors form X-ray exposures while performing close proximity operations during radiological interventional diagnostic and therapeutic. As shown in Figure 1, a protective mask, frame, and suspension bracket consisting of a fixed seat, extension arm, and spring arm combination were included in X-ray Protective Apron system [7, 12]. The protective mask is comprised of lead acrylic, and the protective apron is consisting of a stainless steel frame and curtain including one or more layers of thin, uniform and soft lead vinyl and the outer layer is synthetic leather which is easy to clean. To provide seamless protection from the posterior part to the head, the protective apron is linked to the protective mask. The suspension system carries the weight of the apron and mask, which would not be imparted to the operator. A frame with an elastic contraction capability could automatically tighten the protective apron into a cylindrical shape. Only the belt force control device and the operator's hands are obligated to accomplish the operations. In the cath lab, the protective mask used to protect against X-rays has a height and width of 200 to 250 mm and 900 to 1000 mm, respectively. A protective apron has a length and width of approximately 1000 to 2000 mm. It was estimated that the protective mask and apron carried around 0.5 mm Pb to 2 mm Pb equivalent. A horizontal rotation range of 300 to 360 degree was measured around the axis connecting the arm extension to the fixed seat. An extension arm which has a range between 250 to 300 degree is attached to the spring arm, which swings horizontally around an axis of temperatures. At the front end of the spring arm, there was a 300 to 360 degree vertical rotation of the garments suspended from the spring arm. Angles between -35 and +35 degree were found to fit the height range of operators when the spring arm was oriented horizontally [13]. The present x-ray protective Apron system has been tested consists of a custom-made lead apron, face shield, and left arm flap on a hanger design to be suspended by the operator on a complex motion system that allows for full freedom of movement in three spatial axis (X, Y, and Z) and with zero weight support for the operator (Figure 1). Ideally, the apron should have a Pb equivalent of 1.20 to 1.40 mm in the front and 0.5 to 0.6 mm in the sides. A lead-acrylic clear face shield had an equivalency of 0.5 to 0.6 mm of lead and a thickness ranging from 1 to 20 mm.

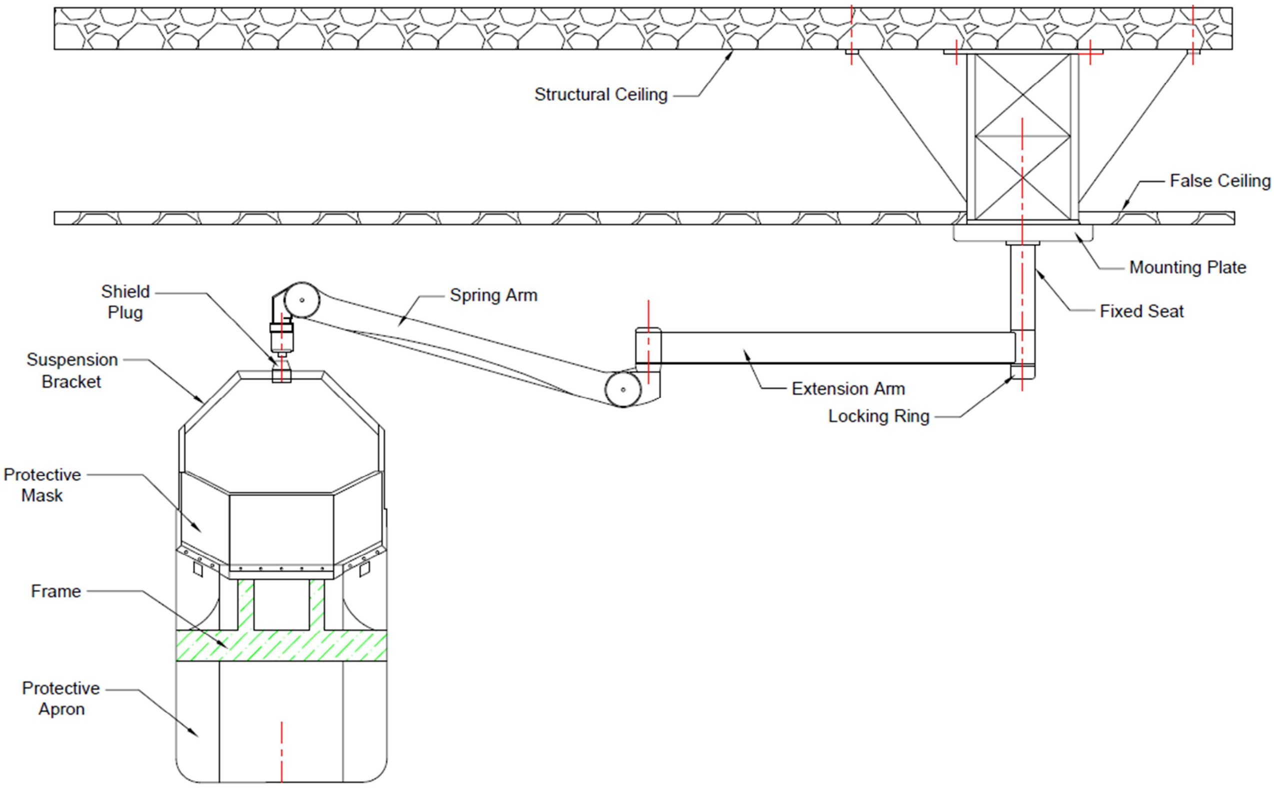

Figure 1. *Design of X-ray protective Apron system.*

3. Result and Discussion

Radiation shield for full body protection provided by X-ray Protective apron system (As shown in Figure 1) was a completely adjustable and portable system that eliminated the need for bulky lead aprons by doctors and their personnel [14]. Wearing lead with this technology is not only more flexible and easier on your joints, but it also reduces the physical strain of wearing it [22]. This also eliminates the need for heavy lead aprons to be worn by physicians. Radiation protection is effectively provided when the under-table lead drapes are used [27, 18]. Extensive and advanced operations can be performed [25]. There are no limitations on the physician's movements or their interaction with their team. With its ceiling-mounted gantry technology, the walk-in suit can be held, which reduces the amount of weight that interventionists must carry with their lead aprons [10, 29]. Gantries enable seamless movement along the X, Y, and Z axis. In comparison to standard lead aprons, the lead apron provides 0.5 to 2 mm lead equivalent protection between the thyroid and groin. Engaging and withdrawing is possible on their own, without help or breaking sterility. X-Ray protective apron system is provided by the device, which removes weight from the body and prevents injury to bones [28]. With an ergonomic design, the top half can be bent easily, and the waistline automatically tightens. Continuous protection of over 0.5 to 2 mm Pb. The suspended body and face protection allows for flexibility of movement and may be conveniently engaged or detached depending upon fluoroscopy usage, all while retaining pristine [25]. There are no restrictions on movement within a radius of 2 to 3 meters. Implements and operates suspension systems efficiently. Shields can be wielded by several arms. Arms have been extended to accommodate a variety of ceiling configurations. For shield, there is a double or multiple arms available. Arms have indeed been lengthened in anticipation for a tight ceiling context.

Radiation reduction with various equipment given in Table 1. The lead apron reduce the radiation more than 90 percent.

Table 1. *Ranges of Reduction in radiation (%) through protective equipment.*

Protective equipment	Reduction in radiation (%)
Radio absorbent surgical caps	3.0 - 4.0
Leaded glasses	30 - 90
Gloves	20 - 60
Thyroid collar	>90
Lead apron	>90

4. Discussion

According to Badawy *et. al.* [2], the radiation protection solutions for the staff provide by radiation shield apron. The apron protect the doctor and patient from the radiation exposure but the high weight of the apron causes the back pain to doctors. Also the apron fit to the body that's why doctor do not move flexibly and operate the patient easily. To solve the problem arises from that device, we develop the radiation X-ray protective apron system that provide the doctors and patients full protection and also it eliminate the weight of heavy apron. Also while maintaining the free range of motion in all three spatial axis during procedures. A conventional interventionalist shield does not provide adequate radiation protection, while the operator is also at risk of developing devastating musculoskeletal diseases from prolonged weight-bearing [17]. The risk of cataracts, thyroid cancer, and lympho proliferative disease may increase for interventionalists due to the high doses of ionizing radiation they receive [26]. In addition to neck and back discomfort, interventionalists also had greater risks of cervical disc herniation, time away from work, and time off work than orthopedic surgeons and rheumatologists because of their lead shielding [4]. In past studies, the operator moved bulky wheeled devices as they moved along with their bodies to lower operator lead weight burden, such as devices that supported the weight of a traditional lead apron without a face shield and a protective cabin that provided more complete protection than a lead apron. This paper describes a X-Ray Protective suspended clothing apron system that protects the operator while reducing radiation exposure and allowing them to maintain their freedom of movement. Comparing the radiation protection provided by the X-ray Protective apron System to a lead apron in a simulated clinical setting, it was 15 to 80 times more effective. When lead eyewear is worn, the face and eyes are still exposed to radiation even with the X-ray protective suspension in place [9]. There is increasing recognition and investigation of radiations harmful effects on the eyes, with the amount of radiation necessary to cause cataracts being lower than previously thought. When simulated patient and operator were used in a laboratory experiment, a pair of glasses provided enough protection, but they weren't as effective as a hanging shield [23]. On the other hand, traditional suspended shields can be difficult to maneuver during clinical work, visually obstructive due to the sterile cover placed over the device, as well as requiring frequent adjustments as tube angulations, the patient position, and changes in the operator's posture are factored in [21]. Due to these limitations, many operators are unable to use shields as often as they need to in order to provide the necessary lens protection. The objective of the x-ray protective x - ray protective apron system is to provide a shield that covers the entire head in all working positions and tube angles without compromising vision or work flow [16]. Meanwhile, the system reduces the operator's weight load in a system that is geometrically positioned for maximum shielding. Lead glasses provide only a modest level of protection to head users, despite dramatically reducing radiation dosage through an anterior position [6]. We must continue to develop specialized radiation safety equipment for peripheral operations and structural procedures. Radiation shielding X-ray protective apron system from the ceiling mounted will provide better radiation protection and avoid orthopedic problems. The ionizing radiation they are exposed to in the course of their work is different from the ionizing radiation patients are exposed to during surgery [30].

5. Conclusion

In conclusion, the X-ray protective apron system provide radioactive shielding from the top of the head to the calves (except the right arm and left forearm) is suspended via an overhead motion system, eliminating weight on the operator while maintaining free range of motion in all three spatial axis during procedures. As the X-ray protection apron system is weightless, it allows for thicker and more extensive lead shielding, as well as reducing the operators musculoskeletal strain.

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