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A Study on the Quality Inspection of Various Life Saving Radioprotective Apparel Using Fluroscopy

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Abstract: ***This study of the quality inspection was designed and performed to evaluate the shielding integrity of the life-saving radioprotective apparel using fluoroscopy. In this study, 125 radioprotective apparel (68 aprons, 48 thyroid shields, 2 gonad shields, 5 lead caps, and 2 pairs of lead leg pads) were inspected for their quality. These radio protective apparel have undergone visual, tactile inspection, and fluoroscopic evaluation on 1000mA fluoroscopy (Shimadzu Flexa Vision HB). Among this quality inspection of 125 radioprotective apparel, 123 apparel are found to be insignificant and tolerable, so that they can be used routinely, and 2 apparel were found to be significant with multiple tears and cracks in it and failed to protect the wearer from radiation. Based on this inspection, it is mandatory to inspect the radioprotective apparel every six months; continuous use will lead to age-related or poor handling defects, often giving rise to multiple tears across the entire radioprotective apparel. We concluded that the radioprotective apparel has to be adequately maintained, and periodical assessment will reduce the unwanted radiation exposure to occupational workers.***

Keywords: Radioprotective apparel, fluoroscopy, occupational radiation workers, secondary radiation

1. Introduction

On November 08, 1895, Wilhelm Conrad Rontgen, a German mechanical engineer, accidentally discovered an unknown ray that fogged the fluorescent screen. As their nature was unknown, he named it X-rays. [1] This momentous invention has led the way and introduced a new discipline called Radiology. Over the decade, the number of patients diagnosed using radiation is growing exponentially. The dangerous effect of radiation on humans is well known; therefore, every precaution and consideration must be taken; perhaps the protective apparel will play an important role. [2], [3] The workers who are regularly exposed to radiation while operating it needs to be sure that they are adequately protected. [4] This radioprotective apparel will act as a shielding material by blocking the radiation and eventually protecting them against the Secondary radiation; Secondary radiation is those that scatter from the patient and the radiation that leaks from an x-ray tube's housing. [2] To protect themself, all radiation workers were instructed to wear radioprotective apparel, which includes an apron, thyroid shield, gonad shield, gloves, goggles, leg pads, and sheets. [4] Conventionally, these radioprotective apparel were made of lead-impregnated rubber or vinyl material with a maximum lead equivalent of 1 mm; this was bulky and heavy, which is uncomfortable for the wearer during prolonged examinations. [3] [4] Recent research papers have done a survey and proven that prolonged use of these radioprotective aprons is associated with the wearer's backache development. [5] Great concern exists about the effects of lead exposure because lead is considered a hazardous material. Even a small amount of lead accumulates in the body will result in Long-term health effects that may develop due to its toxicity. [6] However, protective apparel manufacturers concentrated more on the material used to reduce the wearer's physical stress; this led to introducing lead-free aprons consisting of lower atomic weight materials such as antimony, tin, and barium. [7], [8].

Continuous utilization of these life-saving accessories will pave the way to age-related or inferior handling defects; often cause multiple tears across the radioprotective apparel. [9] Without proper maintenance, these radioprotective apparel will, with time, contribute a great burden to the wearer. [2] [5] So, these life-saving apparel need to be adequately maintained and need to be inspected for the integrity of radiation protection and safety. This study is designed and performed to assess the integrity of various lifesaving radioprotective apparel.

2. Materials and Methods

Equipment and its Operating Parameters

In this study the quality of 125 Radioprotective apparel were inspected using a 1000mA fluoroscopy (Shimadzu Flexa Vision HB). Each apparel undergoes step by step inspection in 20 x 20 cm field of view (FOV) and 120cm source to images distance (SID). For documentation of defective apparel images x-ray were used, at a tube voltage of 70 kVp and tube current of 3.2 mA.

Apparel Inspection

All these 125 radioprotective apparel underwent step by step investigations. They are;

1. Visual inspection

2. Tactile inspection (Palpation)
3. Fluoroscopic Evaluation

The mandatory testing spots on different types of radioprotective apparel were mentioned as the red dot in figure 1.

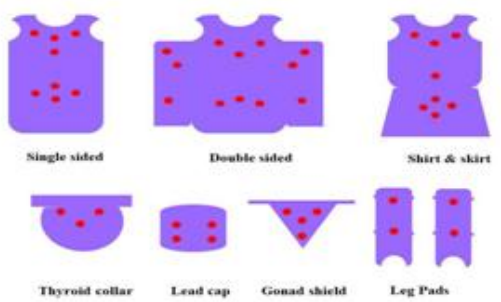

Figure 1: Mandatory testing spots for different types of radioprotective apparel

Visual Inspection

The external physical damages of all 125 radioprotective apparel were inspected through the naked eye. Visual defects include tear of the outer fabric, sticking defects, colour fading defects, and stains. The considered piece of radioprotective apparel is spread out on a flat surface under bright light and visually inspected for the defects mentioned earlier. The doubtable and defective sites were marked as suspicious spots using a temporary marker in the outer fabric for future Evaluation.

Tactile Inspection

The internal physical damages of all the 125 radioprotective apparel were inspected through palpation. Tactile defect includes lead fold, breaks, large lead cracks, and discontinuities in the radioprotective apparel. The considered piece of radioprotective apparel is spread out on a flat surface under bright light and is inspected for the defects mentioned earlier through bare hands, and this way of defects is not directly visualized from outside; this can only be detected manually. The doubtable and defective sites were marked as suspicious spots using a temporary marker in the outer fabric for future verifications.

Fluoroscopic Evaluation

The damages which are identified and not identified by visual and tactile inspections were further evaluated using fluoroscopy. The considered piece of radioprotective apparel is spread out on a floating fluoroscopic table, and the parameters are selected as mentioned above; If the fluoroscopy shows increased transparency or uneven holes, cracks, and tears, then the defects are captured using x-rays. This defective location are marked using a temporary marker on the tested apparel outer fabric cover. Then the results of the defects are archived for future evaluation.

Classification of defects

The defects are classified according to the following scheme with reference to their potential consequences and they require the stated action is described in table. [4]

Table: classification of defects in the radio protective apparel

Classification	Potential damages	Description	Further action
Insignificant	No defects	Was fine	None
	Small defect on the outer fabric of the apparel including sticking & stitching defects	Defects does not significantly harm the protection	None
Tolerable	Defect on the protective layer at one irrelevant location	Defect is insignificant	Should keep an eye on it
	Defects on the protective layers at several irrelevant locations	Defect can evolve into several problems	2nd check after 3 months of usage
	Minor defects on the protective layer at relevant location and lead folds at any location	Defect can evolve into several problems	2nd check after 3 months of usage
Partial significant	Major defect on the outer fabric cover including sticking & stitching defects	Causes discomfort to the wearer	Get it repaired
Significant	Major defect on protective layer at relevant location	protection no longer ensured	Withdraw immediately from use

3. Results

In this single centre study of apparel inspection, we included 68 aprons, 48 thyroid shields, 2 gonad shields, 5 lead caps, and 2 pairs of lead leg pad. Out of these 68 aprons, 36 were single-sided aprons, 25 were double-sided or wrapped around aprons, and 7 were skirt & shirt type aprons.

Results of Aprons

In this inspection of Lead apron, 47 % were classified as insignificant, in which 25 out of 68 aprons had no defect on the it, 7 out of 68 aprons had small defects on the out fabrics.50% were classified as tolerable, in which 5 out of 68 aprons had defect on the protective layer at one irrelevant location, 3 out of 68 aprons had defects on the

protective layer at several irrelevant locations, 21 out of 68 aprons had minor defects on the protective layer at relevant locations and has lead folds on the protective layer, 5 out of 68 aprons had significant defect on the outer fabric cover, 3 % were classified as significant, in which 2 out of 68 aprons had significant defect on the protective layer at relevant location. Classification on the results of lead apron inspection is shown in figure 2.

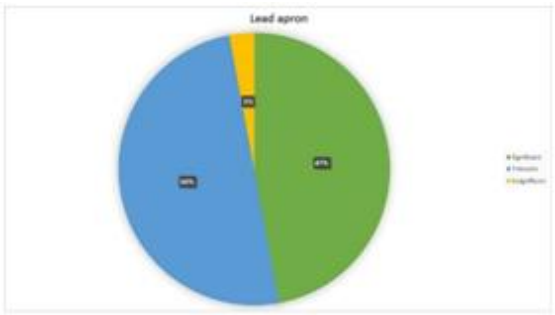

Figure 2: Classification on the results of lead apron inspection

Results of Thyroid Shield

In this inspection, 77 % were classified as insignificant, in which 32 out of 48 thyroid shields had no defect, 5 out of 48 thyroid shields had small defects on the out fabrics, 23 % were classified as tolerable, in which 11 out of 48 had minor defects on the protective layer at relevant locations and lead fold in protective layer at some location. Classification on the results of thyroid shields inspection is shown in figure 3.

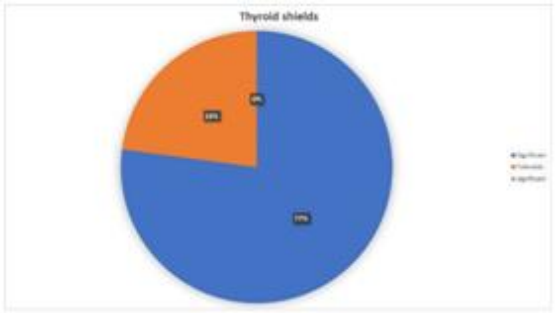

Figure 3: Classification on the results of thyroid shield inspection

Result of Other Radio Protective Apparel

In this inspection, 100% (i. e., 9 out of 9) were classified as insignificant and had no defect in it.

4. Discussion

Occupational radiation workers are the peoples who were educated and trained to use the radiation safely, and they are regularly exposed to radiation while operating it. [2] The interventional radiological (IR) procedures have become the widely accepted technique to diagnose and treat patients. The radiation dose received by the interventional radiology persons will be more than the dose received by the person working in general x-ray examinations. [3], [4], [10] *Roshan S. Lvingstone et, al* has described that the Radiation safety is one of the significant concerns, mainly when speaking about occupational radiation workers. [2] They are more prone to receive radiation exposure to three - tenth of the annual dose limit of 20 mSv recommended for the occupational radiation workers. [11] To reduce the radiation dose received by them, they must wear radioprotective apparel sensibly which act as a shielding material. Most occupational workers will like to wear single-sided aprons, but some will like to wear the double-sided or wrap around or shirt and skirt type aprons during the exposure; this is due to the apron's weight and time of the procedure. Physical strain developed by the wearer during prolonged use of the apron is the often-received feedback. [3] To reduce this physical strain on the wearer, manufacturers have introduced commercially available aprons with reduced weight. The apron's weight was reduced using the lead composite material like bismuth and antimony with adequate Pbeq for radiation attenuation. [2] Though these are commercially available, periodic inspection of this life-saving radioprotective apparel is crucial. The apparel inspection using the transmission ionization chamber is the standard technique, as shown in the literature, [12] an alternate and simple method for inspection of the radioprotective apparel is using fluoroscopy or computed tomography. In this study, the apparel inspection was made using fluoroscopy and this is the choice of method that was used consistently in our institute.

Therefore, the radioprotective apparel which are classified as insignificant were cleaned with the cleaning solutions, labelled with the tested date, next test due date, and reference number for further verifications. Will be Send back to their respective departments for routine uses. The radioprotective apparel which are classified as tolerable and partially significant were sent to the manufacturer to stitch and rectify the stickers and the damages. The radioprotective apparel which are classified as significant is completely removed from the use and contempt safely. The picture gallery of the visual, tactile, and fluoroscopic defects on the radioprotective apparel is shown in figure 4.

Figure 4: The picture gallery of the visual, tactile, and fluoroscopic defects on the radioprotective apparel

A total of 114 apparel were inspected for its quality before 6 months using fluoroscopy, the result of it shows 109 were found to be insignificant, 3 were found to be tolerable with stitching defects and some crack in the irrelevant locations, 2 found to be significant. Which is removed completely from the usage.

It is mandatory to inspect the life-saving radioprotective apparel every half-yearly, i. e., every six months, because continuous use of these accessories will lead to age-related or poor handling defects, in order to reduce it the radioprotective apparel have to be adequately maintained by storing it in the appropriate heavy-duty hanger and rack system under average room temperature. These apparels need to be kept away from the direct sunlight and heat. Should never fold the apparel or hand over edges, and periodical inspection will avoid unwanted radiation exposure to the wearer. The apparel has to be cleaned once in a month or as per the usage. If any stains are marks in the out covering, it must be removed with a soft cloth using warm water and soap solution. Alcohol-free liquid disinfectant can be used to disinfect the radioprotective apparel. [13] This study also suggests that the radioprotective apparel have to be assessed for its shielding integrity from the purchase time by using either Computed Tomography or by using fluoroscopy.

5. Conclusion

It is mandatory to inspect the life-saving radioprotective apparel every half-yearly, i. e., every six months, because continuous use of these accessories will lead to age-related or poor handling defects, which will often give rise to multiple tears across the entire radioprotective apparel. Without routine control and maintenance, these radioprotective apparel will, with time, contribute significantly to the radiation burden to the wearer. Periodic inspection and maintenance will increase the life span of the radioprotective apparel.

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