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QUALITY ASSURANCE OF PERSONAL PROTECTIVE APPAREL AT TERTIARY HOSPITALS IN YOLA, ADAMAWA STATE

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ABSTRACT

Background: Exposure to ionizing radiations is hazardous to radiological workers, patient's relatives and patients. The effect may be stochastic or deterministic. Protective apparel keeps the radiation dose received by hospital workers, patients and patient relatives as low as reasonable achievable (ALARA) under normal working conditions. Protective apparels are frequently mishandled in the diagnostic room after use leading to damage.

Objective: This study aimed at assessing integrity of the protective apparel used at the radiology department of a tertiary health institution in Adamawa State of Nigeria.

Methods: From three different hospitals in Yola, 26 pieces of protective apparels were identified, inspected and classified by the hospital, type, manufacturer's name, years it had been used, and the thickness of the lead. With 17 x 14-inch cassette two exposures were made on each the garment with 70 kVp and 10 mAs with a film focal distance (FFD) of 100cm with a conventional x-ray unit..

Results: The result showed 12 (46.0 %) of the protective apparel studied were defective with split 5 (42.0%), crack 4(33.0%) and hole 3(25.0%) as the most common defect. Correlation of the apparels age and the number of defective protective apparels were statistically not significant (p = 0.166).

Conclusion: In order ensure protective garments provide the best protection possible; there is a need for proper storage and regular quality assurance on the apparels in the radiology departments to ensure radiation protection..

Keywords: Apparel, Integrity, Lead Apron, protection, quality Assurance

Introduction

Since the discovery of X-rays by Wilhelm Conrad Roentgen in 1895, x-rays have been used for both the diagnosis and treatment of patients [1]. Exposure to x-rays and other ionizing radiation is hazardous to the public, radiological workers, patients' relatives, and patients [2]. The effect may be stochastic, in which the probability of occurrence of such effects begins at any given dose and increases as the dose increases, or deterministic, in which the effect begins only when the absorbed dose reaches a certain threshold level, and its severity increases as the dose increases [3]. Protective apparel provides valuable aids in keeping the radiation dose received by hospital workers and patient relatives under normal working conditions as low as reasonably achievable [4].

Personnel, patients, and occasionally patients relatives use personal protective apparel, most commonly lead aprons, gonadal shields, and thyroid shields, to protect themselves from unnecessary ionizing radiation exposure during diagnostic radiological procedures [5, 6]. Protective apparel comes in different forms, shapes, sizes, and thicknesses, they attenuate 90% - 97% of incident scattered radiation at an energy range of 60 kVp to 120 kVp depending on the thickness [5, 7, 10].

Personal protective apparel are frequently mishandled in the diagnostic room after use. Most radiology departments have hangers and racks for proper hanging after use; however, some radiation workers leave them on the x-ray machine table, lead screens (protective barriers), and even on the floor after use when they are contaminated with contrast agent or body fluid during special procedures. Most personnel go for the physically heavy lead apron; however, the ability to protect individuals from the effects of ionizing radiation is not just the weight but also the integrity of the lead in it. Hence the need to assess the integrity of protective apparel at tertiary hospitals in Yola, Adamawa state..

Methods:

A cross-sectional, prospective study design was used for the study. A floor-mounted x-ray unit with an energy output of 125 kVp and a tube current of 500 mA was used to obtain the exposures. While a Konica Minolta computed radiography (CR) system, and a 43 cm x 35 cm phosphor plate cassette were used as image recording systems.

A total of 26 pieces of protective apparel from three tertiary hospitals in Yola were studied, with each apparel being identified by the hospital from which it was obtained, the type, the manufacturer's name, the approximate number of years it had been used, and the thickness. The names of the hospitals were coded H_1, H_2, and H_3 for anonymity.

The outer and inner coverings of the personal protective apparel were systemically subjected to a visual inspection and palpation to check for apparent deterioration, as well as any cracks or evidence of seam separation or sagging. Each protective apparel was spread flat on the tabletop and exposures were made at 70 kVp and 10 mAs with a film focal distance (FFD) of 100 cm, adopted from the University of Iowa Hospital & clinics policy and diagnostics manual [11]. Two exposures were made using a 43 cm x 35 cm Phosphor plate cassette placed in the Bucky tray to cover the upper and lower regions of the apron, and the image was processed using the Konica Computed Radiography system. Measurements of the sizes of the defects was taken using measuring tools found on the CR monitor screen. Data relating to each lead apron were recorded using a data capture sheet, and the images were saved on a CD for review. Data were uploaded to Mendeley and the doi were obtained (doi: 10.17632/23z7hhfp6t.1).

Quantitative criteria for rejection of protective apparel as recommended by Lambert and Mckeon that protective clothing be replaced if defects of greater than 15 mm^2 are identified near critical organs (e.g., breast, gonads, etc.) or if defects greater than 670 mm^2 are identified over non-critical areas (around seams or in overlapping areas). For thyroid collars, if defects greater than 11 mm^2 should be replaced [12].

Data analysis was done using the Statistical Package for Social Sciences (SPSS) Version 16.0. Statistical significance was taken at 0.05% (i.e., P = 0.05). Results were presented using statistical tools such as tables, bar charts, and graphs and described using descriptive statistics of frequency and percentages

Results:

A total number of 26 Personal protective apparel, comprising 17 lead aprons, 3 patient covers, and 6 gonadal shields, were examined, as shown in Table 1. The hospital distribution as shown was: 17 from H_1, 3 from H_2, and 6 from H_3. Most of the personal protective apparel had a lead thickness of 0.5 mm, as shown in Table 2. As shown in table 3 and figure 1, the most common defects on the protective apparel were split 5 (42.0%), crack 4 (33.0%), and hole 3(25.0%). Out of 12 defective apparel, 11 (92%) met rejection criteria (defects near critical organs with sizes of > 15 mm^2), and 1(8%) was accepted. Although visual inspection had suggested some of the protective apparel should be replaced beforehand, the radiograph confirmed the extent of the defects observed. About 83.0% of defects were also noticed in pprotective apparel with no manufacturer's names (Figure 2). The period during which these aprons had been used varied, although there was no documentation on the date of the first usage; however, the manufacturing date found on the lead apron was between 1998 and 2019, with an average age of 8.4 years. The results were statistically insignificant, with a low negative correlation between age of the protective apparel and defect incident: r (24) = - 0.280 = 0.166, with age explaining 7.8% variation in defect incident (table 4)

Table 1: Distribution of different types of personal protective apparel by hospital

Hospitals	Personal protective shield			Total
	Lead apron	Patient cover	Gonadal shield	
H_1	11 (64.7%)	3 (100%)	3 (50.0%)	17 (11.5%)
H_2	3 (17.6%)	0 (0.0%)	0 (0.0%)	3 (11.5%)
H_3	3 (17.6%)	0 (0.0%)	3 (50.0%)	6 (23.1%)
Total	17(100.0%)	3(100.0%)	6(100.0%)	26 (100.0%)

Table 2: Distribution of lead equivalent of personal protective apparel

Protective shield	Thickness(mm)				Total
	0.25	0.3	0.35	0.5	
Lead apron	1(50.0%)	4(80.0)	0 (0.0%)	12(66.7%)	17(65.0%)
Patient cover	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (16.7%)	3(11.5%)
Gonadal shield	1(50.0%)	1(20.0%)	1(100%)	3 (16.7%)	6(23.1%)
Total	2(100%)	5(100%)	1(100%)	18(100%)	26(100%)

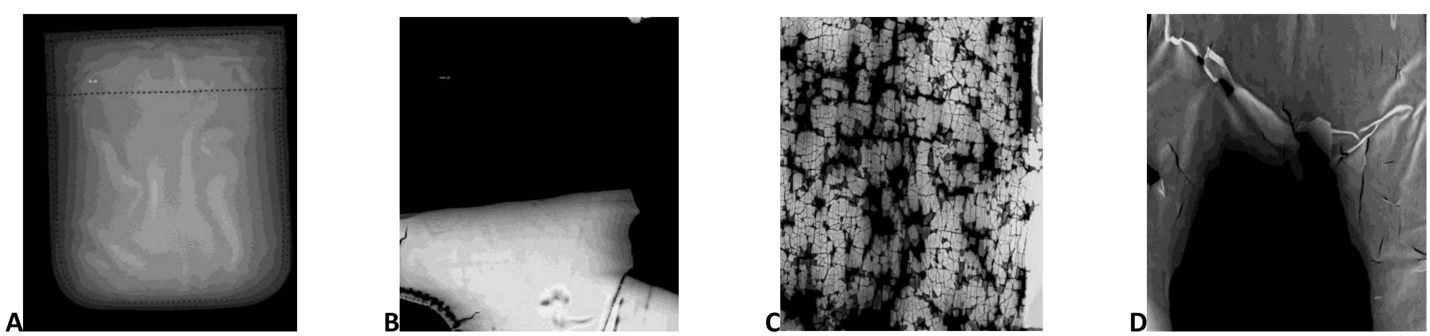

Figure 1: Radiographic images of the protective shield showing different types of defects. Free from defects (A), Splits (sagging), cracks, tears, and holes (B, C, and D)

Type of defect	Accepted	Rejected	Total
Crack	1 (100.0%)	3 (27.3%)	4 (33.3%)
Hole	0 (0.0%)	3 (27.3%)	3 (25.0%)
Split	0 (0.0%)	5 (45.5%)	5 (41.7%)
Total	1 (100%)	11 (100%)	12 (100%)

		Age	Defect
Age	Pearson Correlation	1	-.280
	Sig. (2-tailed)		.166
	N	26	26
Defect	Pearson Correlation	-.280	1
	Sig. (2-tailed)	.166	
	N	26	26

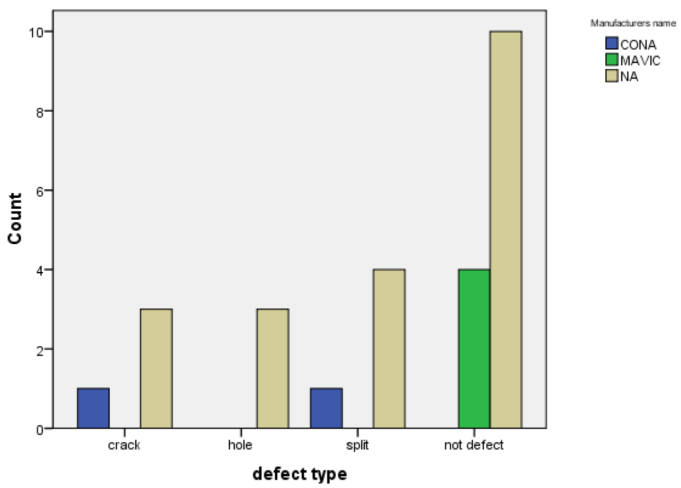

Figure 2: Personal protective apparel by manufacturer names and number of defects

Discussion:

The protective apparel is used to protect users from secondary radiation exposure, these garments are subject to significant wear and tear, especially in busy X-ray facilities, its lifespan ranges from roughly 5 to 10 years, depending on the usage and how it is taken care of [12, 19, 21]. Protective garments, like any other product, should be tested on receipt and should be visually inspected at least every 6 months and fluoroscopically or radiographically inspected at least once every 24 months for the effectiveness of radiation protection [12].

Following the assessment of 26 protective apparel, the results from this study show that up to 12 (46.0 %) of the protective apparel studied were defective, which is higher than the results obtained by Nkubuli *et al.*, [13] and Anas *et al.*, [14] which reported 34.0 %, and 38.8% respectively. However, the findings of this study proved to be lesser as compared to the results reported by Chiegwu *et al.*, [15] and Oyar and Kislaliglu, [3] which were 55.6% and 68.2% respectively.

The study also revealed that the most common type of defect is splits (separation) which account for 42.0% which differs from the results obtained in other studies where cracks were the major defects, accounting for 44% [16], 60% [15], 56.25% [13], and 70% [17]. The protective apparel's integrity deteriorates as it ages; however, the level of damage observed on the aprons was not necessarily dependent on the age of the apron but may also be attributed to poor handling by the users, as folding and dropping of aprons were observed in some of the hospitals, which could be one of the major causes of rips, cracks, and holes in the protective apparel. Similarly, the correlation between the apparel age and the number of defective apparel was not significant ($p = 0.166$).

Some of the defective areas in the lead aprons were close to the lower part of the aprons that is supposed to protect the sensitive organs like gonads with a high tissue weighting factor, as classified by Oppliger-Schäfer and Roser, any major defects on protective layers at relevant locations should be withdrawn or repaired immediately [18]. About 11 (92%) of the defects observed exceeded the maximum area 15 mm^2 and 10 cm^2 for rejection and replacement as recommended by Lambert & McKeon [12] and Duran & Phillips [20], as well as Sam & Pillay [4], which states that the maximum tolerable length of a defect on a whole-body garment with the lead equivalent of 0.25 mm, 0.35 mm, and 0.5 mm should not exceed 5.4 cm, 5.6 cm, and 5.9 cm respectively. Furthermore, about 83.0% of defects were noticed in protective apparel with no manufacturer's name, which is in tandem with what was recorded by Ukpong [16], who reported 81%

of defects found on the apron with no manufacturer's name.

It has been noted that most of the defects found in this study are in agreement with a study conducted by Bawazeer [21], which stated that body aprons were more likely to damage than other protective garments; this could be a result of frequent usage. It is recommended that X-ray racks and hangers be used to safely hold the protective garment when not in use [22], and protective garments should be checked for integrity annually [23]. As a result, we recommend that protective apparel with significant defects be replaced, and new apparel should be tested for integrity upon receipt (an "acceptance test") and management should avoid the procurement of low-quality protective apparel because such apparel is incapable of providing the needed radiation protection to the users and are prone to defect before their expected life span. Management should involve or seek advice from experts and end users when procuring.

In conclusion, the research revealed that a significant number of the protective garments were defective, with spits, cracks, and holes as the major defects observed, which are indicative of improper care of the protective apparel. To ensure protective garments provide the best possible protection, there is a need for proper handling and regular quality assurance on the apparel in the radiology departments to ensure radiation protection. The first step towards this is to ensure that the protective apparel is tested for radiation protection efficiency before purchase or receipt as recommended by regulatory agencies.

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