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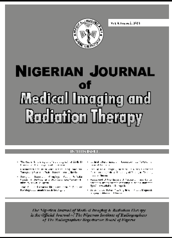

EVALUATING THE INTEGRITY OF LEAD APRONS IN SOME SELECTED PRIVATE AND TERTIARY HOSPITALS IN SOUTH EASTERN NIGERIA

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ABSTRACT

Objective: To determine the percentage of scattered radiation absorbed by lead aprons used in the radiography department of some private and tertiary health care institutions in south eastern Nigeria.

Methods and Materials: Six lead aprons were selected from different private and public hospitals. Two thermoluminiscent dosimeters (TLD) were placed at the outer and inner surfaces of the chest region of the aprons to measure the incident and transmitted doses respectively. The aprons were placed at 1m from an x-ray tube away from the primary beam, and an exposure of 80kV and 32 mAs was made. Results were presented using tabes and graphs, while test of association between age and attenuation of scatter radiation was determined using eta squared

Results: The lead aprons absorbed between 8.7 – 71% (0.02 – 0.45mGy) of scatter radiation incident on it. Their ages were associated with the amount of scatter radiation absorbed (eta squared=0.658), and both parameters had a strong, negative, but insignificant relationship ($r=-0.76, p=0.06$).

Conclusion: The scatter radiation attenuation capabilities of the lead aprons in the hospitals studied were poor and exposed personnel to increased radiation per use.

INTRODUCTION

During radiographic examinations, protective aprons are the primary source of shielding from scatter radiation to patient relatives, radiographers, radiology nurses, and other ancillary staff in the radiography department. These aprons, depending on their quality, are made of various thicknesses of lead or lead equivalent materials [1]. Non-lead aprons are preferable as they have lighter weight, are less clumsy to handle, have less tendency to develop nicks and cracks, has even been shown to have a higher protective effect than their lead counterparts[2], and are less toxic[3]. Johansen et al–[4] compared Antimony-Bismuth based lead aprons with lead rubber aprons and found comparable scatter radiation attenuation properties at beam energies of between 60 – 113kvp. However, despite lightweight and ergonomic advantage, the integrity of lead and non-lead aprons can still be compromised with or without any apparent physical damage. Matsuda and colleagues [5] used computed tomography scout imaging to study the integrity of lead aprons that have been used for more than six years but had no apparent damage from visual and tactile assessment, and observed damaged internal shielding, which predisposed users to risk of radiation exposure. A standard lead apron for use in hospitals is expected to attenuate between 75 – 90% of scatter radiation incident on it[6]. Livingstone[7], in a bid to develop a simple quality assurance test tool for newly purchased lead aprons, tested the absorption capability of new lead aprons and recorded between 90 – 95% attenuation of incident radiation, both for lead and non-lead aprons. Conversely, a study have demonstrated that under normal working conditions, users of apparently normal protective aprons can be exposed to high levels of scattered radiation—[8], a possible cause being the acquisition of substandard aprons"[9]. Also, a large percentage of lead aprons used in hospitals look normal but upon radiological examination, have developed cracks and are more radio parent than the defined local limits"[9, 10]. In a study by Chiegwu et al[11] on the integrity of lead aprons in some Nigerian hospitals, they noticed that all the lead aprons studied had cracks and holes, and had poor attenuation of scattered radiation incident on it, with values far below acceptable standards. These studies call to question the general integrity of the lead aprons that are used in radiography departments in private and public healthcare institutions. A disturbing but plausible hypothesis is that the use of lead and non-lead aprons as accessories for protection from scatter radiation gives users a false sense of protection. Protective aprons are a common feature in the radiography department, and quality assurance exercises are meant to identify these lead aprons for replacement. However, these aprons may be used for longer than the stipulated period without being replaced. In this study, we evaluated the integrity of protective aprons used in some private and tertiary hospitals, assessing their physical state and their attenuation to scatter radiation by simulating a radiographic examination where the aprons are used.

MATERIALS AND METHODS

This is a cross-sectional prospective study conducted in private and tertiary hospitals. A total of six lead aprons were selected, one from each centre. The aprons were inspected for physical signs of nicks and cracks. The diagnostic room was set up to simulate a tabletop radiographic examination, with the lead apron mounted at a distance of 1m from the x-ray tube. The primary beam was directed perpendicular to the x-ray couch. Two thermoluminescent dosimeters (Dosimetry Company of Cincinnati, speed of 100) which have previously been annealed using a Harshaw 3500 machine that used a planchet heating mechanism were mounted outside and inside each lead apron (Figure 1). This was set up to measure the scatter radiation incident on the lead apron during exposure and the radiation transmitted by the lead apron. When the setup was complete, a single exposure was made at 80kVp and 32mAs. The TLDs were then extracted and sent for reading. The percentage dose absorbed by each lead apron was calculated thus:

$$\frac{\text{Incident dose} - \text{Transmitted dose}}{\text{Incident dose}} \times$$

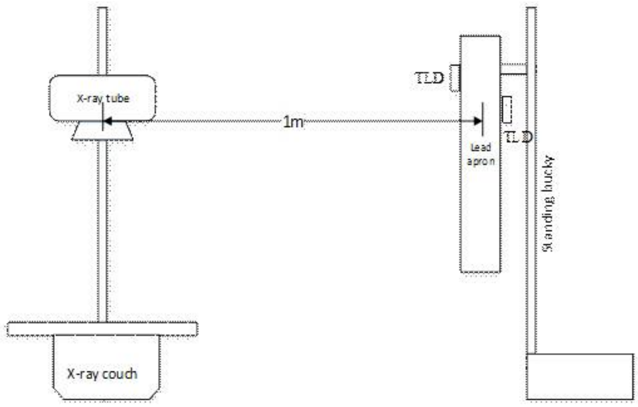

FIGURE 1: SET UP FOR LEAD APRON TESTING SHOWING POSITIONS OF THE LEAD APRONS

Results we presented using graphs and tables, while eta squared was used to determine if there was an association between the age of lead aprons and the amount of scatter radiation that was absorbed. A line graph was equally used to demonstrate how attenuation of scatter radiation varied with age of the lead aprons.

RESULTS

The shield aprons used in this study were all lead-based, medium to large-sized, and were between 2 and 10 years old. Except for one of the aprons, the lead equivalent thickness was 0.35mmPb (Table 1). The amount of scatters radiation absorbed by the lead aprons ranged from 8.7% (0.02 mSv) – 71.4% (0.45 mSv), with percentage transmitted dose between 28.6% and 91.3%. (Table 2). In general, the amount of scatter radiation absorbed by the lead aprons decreased with age (Figure 1). A test of association revealed that the age of the lead aprons was associated with the amount of radiation they absorbed (eta squared = 0.658), and a Pearson's correlation of both parameters demonstrated a strongly negative albeit insignificant relationship (r

= 0.76, p = 0.06). The data used for this analysis is available[12].

TABLE 1: GENERAL FEATURES OF THE LEAD APRONS EVALUATED

Apron	Manufacturer	Size	Thickness (mmPb)	Age (years)
1	Nil	Medium	0.35	10
2	Nil	Medium	0.35	10
3	Mavig RA 660	Medium	0.50	4
4	Nil	Medium	0.35	7
5	Nil	Medium	0.35	10
6	Wardray Promise	Large	0.35	2

TABLE 2: ABSORBED AND TRANSMITTED DOSES OF THE LEAD APRONS

Apron	Incident dose (mSv)	Transmitted dose(mSv)	Absorbed dose(mSv)	Absorbed dose (%)	Transmitted dose (%)
1	0.26	0.19	0.07	26.92	73.08
2	0.32	0.16	0.16	50.00	50.00
3	0.69	0.31	0.38	55.07	44.93
4	0.31	0.15	0.16	51.61	48.39
5	0.23	0.21	0.02	8.70	91.30
6	0.63	0.18	0.45	71.43	28.57

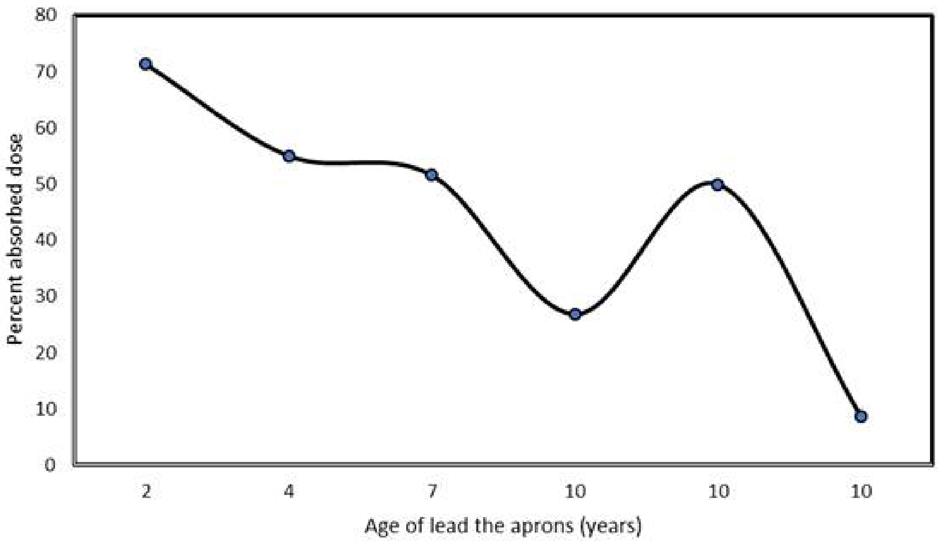

FIGURE 2: PERCENTAGE ABSORBED DOSE AGAINST THE AGE OF THE APRONS

DISCUSSION

Radiation protection is one of the major responsibilities of every radiographer towards patients and the public at large. The use of protective lead and non-lead aprons is a readily available option for shielding as a means of radiation protection. This function would be altered if protective aprons adopted for use in hospitals and believed to protect from secondary radiation during radiographic examinations are subsequently found to be inefficient[11]. This will mean that its users were being exposed to secondary radiation unknowingly. Testing of lead aprons for integrity is relevant to assess their efficiency, and this can only be achieved via routine quality assurance checks. If this is not done, the users enjoy a false sense of security whereas they are exposed to a considerable amount of radiation.

The findings of our study demonstrated that the lead aprons used in the hospitals were poorly taken care of. There were physical nicks and cracks on their surfaces, except for the newest lead apron that was about 2 years old, findings which have previously been reported. Oyar and Kişlalioğlu[13] studied the physical features of eighty-five protective lead aprons and noted that half of them were in poor conditions as regards nicks, cracks, and bends, all of which contributed significantly to their failure to shield the users. A study in South Africa involving 87 lead aprons used in operating theatres revealed that half of them were found to be unsafe for use, where a subset of these unsafe ones had several defects"[9]. A similar study in Asaba revealed that up to 80% of the lead aprons being used were defective[14]. All the aprons used in our study were lead-based and consequently heavy and clumsy to handle. We think that this might have contributed to their poor usage and storage conditions. We opine that if they were lightweight like the non-lead apron variety, they could have been in better shape physically and therefore less likely to develop nicks and cracks.

Results from absorption efficiency of the lead aprons revealed that scatter radiation incident on the aprons were poorly attenuated. The incident scatter radiation dose on the lead aprons ranged from 0.23 – 0.69 mSv, and except for the new apron that absorbed 71.4% of incident radiation, the rest absorbed between 8.7 – 55.1% of the incident radiation. Our reports are similar to what was recorded by Hyun and colleagues—[8], who reported that the aprons absorbed only 1/3 of the incident scatter radiation, with time and distance reducing radiation exposure to the user by up to 62.5%. exposure time even when the lead aprons were used It is evident that age plays an important role in the absorption efficiency of the lead aprons, as was shown by a significant association (eta squared: 0.76) and a strong negative relationship ($r = -0.76$, $p = 0.06$). In general, the absorption efficiency of the lead aprons decreased with age. Protective aprons are often overlooked in the department during quality assurance and replacement of accessories. This may be because the lead aprons do not show an external sign of inefficiency or degeneration, and may still appear physically intact, especially for the newer and flexible ones. This will lead to is use extended beyond the required period for replacement. It is pertinent that the lead aprons are constantly tested because the use of inefficient lead aprons leads to a false sense of radiation security and hence consequent overexposure to radiation. Our study further reports an association between the age of the lead aprons and the amount of absorbed scatter radiation. As the lead aprons get older, they are prone to degeneration from occasional or constant use depending on the workflow of the department. We believe that lead aprons should be changed after 5 years of use as that is the period from our study that the aprons lose more than 25% of their attenuation capability. Another author in a larger study noted that protective aprons that have been used for more than six years had more defects and absorbed lesser scatter radiation than their younger counterparts [5]. The strength of this study lies in the fact that the lead aprons were tested in a simulated environment that matched their use and this gave a precise estimate of the amount of scatter radiation they absorb. However, this study could have been more robust if there were a larger number of lead aprons available for the study, but that was the number of aprons available and in use in the hospitals and private centers studied.

In summary, the lead aprons used in the clinics studied performed poorly in radiation protection of its users, absorbing less than half of scatter radiation incident upon it and giving a false sense of security against radiation. We suggest that newer lead aprons to be acquired by hospitals should be non-lead based, flexible, and lightweight. Upon purchase, they should be tested to determine the actual amount of scatter radiation they absorb, and not relying necessarily on manufacturer's specifications as there may be discrepancies between absorbed radiation values reported by manufacturers and independent tests Furthermore, integrity tests should be repeated every six months to monitor the rate of degeneration. We recommend that the lead aprons should be changed after 5 years of normal use. Additionally, storage and handling could further be improved to increase the longevity of these aprons.

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