Contents lists available at

Journal of Association of Radiographers of Nigeria

Journal homepage: www.jarn-xray.org

An Assessment of the Lead rubber aprons in Radiodiagnostic centres in South-South Nigeria

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ARTICLE INFO

Article history
Received 4th May 2010
Received in revised form 16th October 2010
Accepted 11th October 2010
Available online October 2010.

Keywords:
Lead apron, defect, radiation, protection, faults, radiology centre

ABSTRACT

Background of Study: Radiation protection is of core importance in radiodiagnostic centres, to keep both patients care givers and staff of the centres from stochastic and non- stochastic effects of radiation. The effectiveness and protectiveness of aprons are of valuable importance, it is therefore necessary to assess these aprons to ensure efficacy. Such quality checks have not been reported in the South – South region of Nigeria.
Aim: To assess in terms of their quality and therefore protective features, the lead aprons in used radiology clinics in the South-South region of Nigeria.
Method: Twenty two protective lead aprons from 18 radiological clinics in South-South Nigeria were directly exposed to X-rays with average factors of 70 ± 5kVp, 16 mAs and 100 cm Source to apron distance, with 43 x 35 cm cassettes places underneath to cover the upper (thoracic half) and the lower (abdominal half) respectively. Exposed films were processed in each centre following regular processing protocols to obtain radiographs with images of the state of the aprons. The images were analyzed on the basis of each apron's lead equivalence (content), age, brand and the type of defects observed. Defects were characterized into cracks, tears, splits and rips. Physical examination for cleanliness, wear and tear was also carried out.
Results: Results showed that 68% of all the aprons under study were defective, having cracks (44%), tears (33%), splits (15%) and/or rips (8%). About 73 % of the defective aprons had more than one (1) type of defect. Up to 87% of the defective aprons had no inherent lead equivalence and manufacturer identification indicated on them. It was observed that about 73% of these defects occurred in aprons of aged between 1-10 years with the area affected in the range of 1.00 – 1000.00 mm^2.
Conclusion: Over two-thirds (⅔) of lead aprons found in diagnostic radiology centres in South – South Nigeria, have shown sufficient evidence of defects to suggest that they may not be useful for radiation protection of the users.

INTRODUCTION

In order to keep the radiation dose received by patient's caregivers and hospital personnel as low as reasonably achievable (ALARA), lead aprons are provided as valuable aids [1]. Their specific function is to provide shielding against secondary radiation. Practically, lead rubber aprons are used during a variety of diagnostic imaging procedures including angiography, fluoroscopy, mobiles and theatre procedures and are designed to shield approximately 75% of radiosensitive red bone marrow. They may reduce the dose of radiation received by over 90% (85% - 99%) depending on the energy of the X-rays and the lead equivalent thickness of the apron [2].

The medical Guidance note [3] issued by the Institute Of Physics And Engineering a Medicine (IPEM) regarding protective clothing states that "Body aprons should be available with a protective equivalent of not less than 0.25mm lead for x-rays of 100kVand not less than 0.35mm lead for x-rays over 100kV [4]. Intensive use of this accessory could lead to age related or poor-handling defects. Lead aprons are very effective personal radiation protection means. Without routine checks these lead rubber aprons could, with time contribute significantly to the radiation burden of the wearer. Lead rubber aprons may develop defects when used over a long period of time especially when the working life has been exceeded[5]. Local defects may not necessarily lead to gross changes in the radiation dose received by the wearers. For this reason the location and size of defects are important in evaluating whether a lead apron would need replacing or more frequent control [1]. A routine check is therefore recommended yearly[6]. Two methods of testing, direct (with the primary beam) and indirect (with secondary radiation), have been recommended for lead apron checks [7,8].

Observation has revealed that once acquired, lead aprons are seldom tested or even replaced. As a result there have been questions bothering on the effectiveness of lead rubber aprons for personnel safety in most radio diagnostic centers in Nigeria. This necessitates an investigation of the status of aprons and the need for routine checks in radiological centres. The recommended lifetime of a typical lead rubber apron with proper care is in the order of 10 years. However, observation has shown aprons of over 10 years in use in many centres across the Nigerian nation. It is therefore important to evaluate the effectiveness of these lead rubber aprons.

This work reviews the state of lead aprons and the nature of defects in South-South region of Nigeria to ascertain their effectiveness in attenuation of secondary radiation incident on them.

MATERIALS AND METHODS

A total of twenty two (22) lead rubber aprons drawn from 18 diagnostic radiology centres were examined in the study. Each lead rubber apron was subjected to direct radiographic exposures using a 35 cm by 43cm cassette, with the exposure aimed at the thoracic and abdomino-pelvic regions, respectively. The direct approach was chosen over the indirect method because of the wider spectrum of energies available for assessment of apron performance. Other sections not covered by the broad demarcation (thoracic and abdomino-pelvic) were exposed separately to rule out defects out-with the two broad regions. Exposures were made with an average kVp of 70 ± 5, a tube current and time product value of 16 mAs, using a focus to apron distance of 100 cm. Aprons that were double sheet (front and back) were examined using the same method on both sides. Exposures were made on the lead rubber aprons with the area of interest placed over the unexposed, loaded cassette.

Exposed films were processed using each centre's clinical protocol to obtain images of the respective parts of the aprons. The method of processing did not matter since the intention was to simply identify and isolate defects or faults on the aprons. The defects in the lead rubber aprons were identified following inspection of the processed films as appearance of densities in a fashion or pattern that indicated either a tear, crack, rip and splitting of the lead. The number and form of defects were recorded.

A physical examination was then performed to assess the following; Age, Wear and tear, general cleanliness of the exterior surface of the aprons, lead equivalence of each apron, the name of the manufacturers and ways of handling of the lead aprons, though proper ways of handling, wear and cleanliness of the exterior surfaces of the aprons were not analyzed in this research.

RESULTS

Results revealed several defects in the form of tears, cracks (Figure 1) as well as splits and rips (Figure 2). The brands of aprons studied, the number, ages and number of defects obtained is presented in Table 1.

It was found that at least 53% of all the defects were observed on aprons of ages 1-5 years (Table 2). Aprons within age range 1-20 years were found to be defective, while those from 36-45 years had rather surprisingly no defects. It was observed that 73% of the defective aprons had more than one type of defect. Table 3 shows that the aprons which had inherent lead content indicated on them had fewer defects (13%). On the other hand, the aprons which had no lead equivalence indicated, recorded the highest number (87%) of defects.

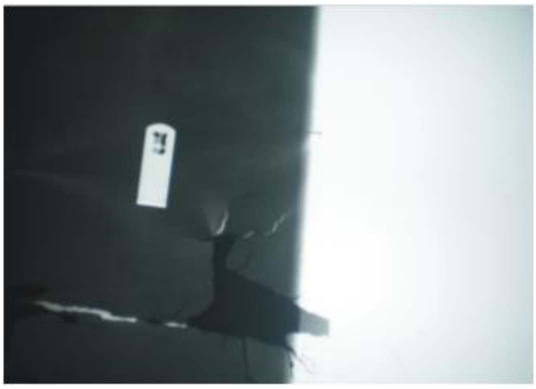

Figure 1:An image of a section of a lead apron with Tear and crack defects

Table 1: Distinction of Lead apron by manufacturer, age and number of defects

MANUFACTURER	NO. OF APRONS	NO. OF DEFECT	AVERAGE AGE (YEARS)
PILMEDICAL	2	NIL `	15
SCANTEX	3	3	7
WALF	3	NIL	43
MECK BRAND	1	NIL	2
NA	13	12	7

A significant number of defects were noticed also in aprons with no manufacturers' names. At least 81% of the defects occurred in these category of aprons (Table 1). Table 4 shows the sizes of the observed defects in different regions of the aprons under study. It was observed that the area of defects were in the range of 1.00 – 1000.00 mm ^{2}. About 67% of aprons were in this category. These defects were mostly on the left and the right sides of the aprons, the midsections having fewer defects. Most of these defects were crack (44%). About 33% of these were tears, 15% split defects and 8% were rips (Table 5).

TABLE 2: AGE/DEFECT

AGE(YEARS)	TEAR	SPLIT	CRACK	RIP
1-5	8	6	2	3
6-10	3	3	3	0
11-15	2	1	1	1
16-20	2	1	2	0
21-25	NA	NA	NA	NA
26-30	NA	NA	NA	NA
31-35	NA	NA	NA	NA
36-40	0	0	0	0
41-45	0	0	0	0

Some aprons had more than one defect.

TABLE 3: LEAD EQUIVALENCE OF APRONS/DEFECT

LEAD EQUIVALENT(MM)	NO. OF APRONS	NO. OF DEFECT
0.5	3	NIL
0.35	4	2
NA	15	13

TABLE 4: SIZE OF DEFECT/ NO. OF APRONS

SIZE OF DEFECT (mm^2)	NO. OF APRONS WITH DEFECT
1-100	10
101-200	2
201-300	NA
301-400	1
401-500	1
501-600	NA
601-700	NA
701-800	NA
801-900	NA
901-1000	1

TABLE 5: REGION AND NUMBER OF DEFE CTS

DEFECT TYPE REGION		CRACK	RIP	TEAR	SPLIT
THORAX	RIGHT	3	-	3	3
	MIDDLE	2	1	2	2
	LEFT	7	1	2	-
ABDOMEN	RIGHT	6	1	4	3
	MIDDLE	1	1	1	-
	LEFT	4	1	6	1

DISCUSSION

The results from this study reveal a high degree of defective aprons in use in the centres under study. This could be attributed to a lack of maintenance culture observed in most radio diagnostic centres in the South –South of Nigeria. The lack of quality control programmes in all the centres surveyed may also be a reason for the results obtained. Nonexistent quality assurance programmes has been reported by other authors [9,10]. Information obtained from all the centres reveal that no checks on the aprons had previously been carried out. This is confirmed by the level of damage noticed in the aprons. An apron with as much as 900 mm^2 of defects would expose the patient's caregiver or even the staff wearing them to significant quantities of secondary radiation. This reduces the aprons to mere materials lacking the capacity to provide the required benefit to their user.

An apron is meant to reduce the dose of radiation received by a user by over 90% (85% - 99%) depending on the energy of the X-rays and the lead equivalent thickness of the Apron [2]. The level of damage observed on the aprons was not necessarily dependent on the age of the apron but may also be attributed to handling by the users. Guidelines have been suggested for handling of aprons and caring for them. It is recommended that aprons are hung up straight when not in use [4]. However, folding and dropping of aprons were observed in some of the centres. These may be one of the major causes of cracks in the lead rubber fabric.

Another recommendation is the undertaking of monthly visual inspection of aprons. It was observed that some aprons had exceeded the recommended life time of 10 years [7]. It was noted in some centers that the life span of aprons was prolonged more from a lack of use than from care in handling them. Equally, some of the aprons with defects might have been due to abuse.

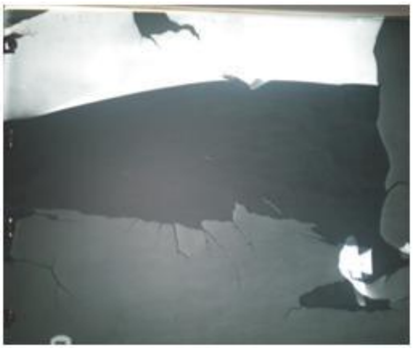

Figure 2: An apron with splits and rips defects

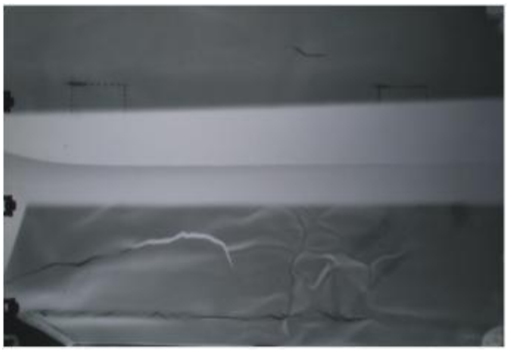

Figure 3: An apron with crack and tear defects

Non lead materials have been used as aprons in diagnostic radiology procedures [11, 12]. Notwithstanding, it is required that aprons produced are made to last and have sustained effectiveness in function. About 62% of lead aprons studied had no manufacturers' names on them. This may be evidence of the centres' patronage of low quality and cheap products. The result of this study showed that although these aprons had not exceeded their lifetime, they showed a high presence of defects. Such aprons obviously would be incapable of providing radiation protection to the user, as their use could increase radiation dose absorbed by the user above acceptable limits. This however would need to be tested by conducting radiation permeability tests on each apron. Regular quality assurance and performance checks in this respect are recommended.

CONCLUSION: This study reveals that lead aprons used in the South-South region of Nigeria are mostly defective. The issue of routine checks on lead aprons used in diagnostic centres should be given priority due to the fact that lead aprons are of utmost important as shielding equipment against x-rays. Radiodiagnostic centres in this region should commence this simple, cost-free means of ensuring that lead aprons conform to required structural standards. This work will serve as a basis for further assessment of lead aprons which will include measurement of permeability of defective aprons.

Acknowledgement
The authors are grateful to the management and staff of all the 18 diagnostic outfits that were visited in this study.

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