Indian Journal of Science and Technology Vol. 4 No. 11 (Nov 2011) ISSN: 0974- 6846

The assessment of shielding status of conventional radiographic rooms according to the National Council on Radiation Protection reports No.49 and No.147 and recommendation to national and international authorities of radiation protection to prevent wasting shielding costs of conventional radiographic rooms

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Abstract

A decade after the invention of X -ray machines, radiographic rooms shielding became one of the major concerns of the scientists related to radiation, so that after 100 years after the invention of X-ray machines, there are still some discussions in national and international reports concerning this issue. One of the significant reports is that of National Council on Radiation Protection, so that in the reports No.49 and 147, this council paid comprehensive attention to radiography rooms shielding. In this study, the reports No.49 and 147 of NCRP was invoked, and considering the radiographic rooms design under study and also radiographic devices profiles used in each radiographic room, the shielding needed to each radiographic room was separately calculated and evaluated according to the reports No.49 and 147 of NCRP. In the next step, the calculated shielding thickness for each radiographic room compared with the shielding used in each radiographic room, and some recommendations presented for preventing wasting the finance resources along with proper shielding of radiographic rooms. For this purpose, the number of exposures to each radiographic room along with the amounts of mAs and kvp used for each patient collected for 6 months for calculating the shielding needed for each radiographic room, and the workload data was precisely determined for each device. In the next stage, the shielding thickness needed for each radiographic room was calculated in two ways: 1. According to the NCRP report No.49, and 2. According to the NCRP report No.147. The calculated shielding thickness was eventually compared with the shielding thickness used in each radiographic room. This study show that the shielding thickness used in radiographic rooms under study is usually higher than calculated needed shielding, so that building thickness of radiographic rooms under study has been sufficient for required shielding and there was no need to lead knocking the rooms. The accurate calculation of shielding needed for radiographic rooms according to national and international recommendations causes the radiation protection principles to be observed and also the national capitals wasting prevented. In this study, the unnecessary shielding costs of radiographic rooms is nearly 10000 $ in only six radiographic centers under study, which cause a large part of the national capital to be wasted at the macro level.

Keywords: radiation protection, radiography room, shielding, NCRP, Sistan and Baluchestan

Introduction

The proper shielding of radiographic rooms plays a key role in reducing the radiographer's absorbed dose. National Council on Radiation Protection and Measurements (NCRP), presents guidelines for radiographic rooms shielding in the reports No.49 and 147 (NCRP, 1976,1993, 2004) which form the basis for most countries in designing radiographic rooms and shielding.

NCRP report No.49 recommends the annual dose limit for radiation workers and general public is 50 mGy and 5 mGy respectively (Archer, 2005; Archer & Gray, 2005). This dose limit was reduced for both radiation workers and general public in the next NCRP reports No.116 and 147 (Gray, 1994), so that this annual dose limit was reduced as 5 mGy for controlled areas and 1 mGy for non-controlled areas, but using the new dose limits along with the calculation method presented in the NCRP report No.49, has significantly increased the shielding thickness needed for radiographic rooms, and the needed shielding thickness achieved more higher compared to what was used in radiographic rooms that it was so criticized by many scientists (Simpkin, 1987; Gray & Archer, 1994; Simkin, 1996; Petrantonaki, 1999), because the amount of radiographer's absorbed dose recorded and attained by beige films indicated that the amount of shielding thickness used in radiographic rooms which was aimed for reducing radiographer's dose was much less than determined dose limits, and there was no need to increase the thickness (Borasi & Ferressti, 1989; Costa & Coldas, 2002).

Therefore, new guidelines presented for designing and shielding the radiographic rooms in the NCRP report No.147 in 2004. It was also mentioned, in this report, that the radiographer's dose was annually reduced to 5msv for controlled areas and the general public dose limit was also reduced to 1msv for non-controlled areas. This report also presents new guidelines levels for occupation factors and use factors which is more valid. The information related to task group No.13 conducted by Simpkin has also been implemented. The numbers of patients were determined by weekly mean, kvp

Indian Journal of Science and Technology Vol. 4 No. 11 (Nov 2011) ISSN: 0974- 6846

distribution and the factor used in radiographic rooms in considering the Simpkin's diagnostic radiographic machines workload (Simpkin, 1987; Simpkin, 1996).

In addition, the radiation attenuation by patient, image receptor and the structures of image receptor maintenance have also been considered in the initial shielding designing in the NCRP report No.147, whereas the radiation attenuation has been neglected through this factor in the NCRP report No.49 (Gray & Archer, 1994; NCRP, 2004).

It is worth mentioning that the designing rules and calculations related to shielding has not generally been observed in most radiographic rooms, and a specific thickness of lead knocked on the wall merely after making the radiographic room, whereas measuring the shielding thickness needed is highly significant for both radiation protection of radiographers and preventing finance resources wasting in a community and should be paid attention to authorities. However, even the calculations had already been conducted, the calculations has been performed according to the NCRP report No.49 in most radiographic rooms designed and made many years before, which reviewing the primary and secondary shielding of the designed radiographic rooms in the last years seems necessary by issuing the NCRP report No.147 and presenting the new dose limits and also providing the new amounts of workloads and occupation factors in this report. The measurements related to primary and secondary shielding thickness needed for 6 radiographic rooms was separately conducted according to the two NCRP reports No.49 and 147 in this study, and the calculated shielding thickness was compared with that of used in these rooms.

Materials and methods

Workload determination

The accurate amount of workload for each radiographic machine for calculating the shielding thickness is needed for each radiographic room. To obtain this purpose, the amounts of mAs and kvp adapted for each patient, the number of exposure needed (inclusive of repetition) for each patient and the imaging technique used in all radiographic rooms were collected for 6 months, and then workload mean for each radiographic room was calculated (Table 1).

The geometry and features of radiographic rooms

The building map of all radiographic rooms and their environments was designed in this stage, and the tube distance of X-ray to ceiling, floor, walls and also the lead thickness used in each primary and secondary barrier was obtained. The building thickness of the walls, ceiling, and floor of radiographic rooms was separately calculated. It is worth mentioning that the walls, ceiling and floor of radiographic rooms under study was of concrete in some rooms and of brick in some others, which a thickness equal to lead was calculated in each one concerning the regarded shielding thickness and also the density of constructed material.

The primary and secondary barrier's thickness of radiographic rooms were separately calculated according to each NCRP reports No.49 and 147.

The following equations were used for conducting primary and secondary shielding of radiographic rooms according to the NCRP No.49:

$$B = \frac{Pd^2}{WUT} \quad (1)$$

$$\mathbf{B}_s = \frac{p(d_{sec})^2(d_{sca})^2 400}{aWUT} \quad (2)$$

In this equations B and B_s indicate primary and secondary transmission factors respectively, P is permissible dose (currently dose limit) according to the NCRP report No.49 and W, U and T are workload, use factor and occupation factor, respectively. In addition, in equation 2, which is concerned with calculating secondary thickness, F indicates radiation field size based on cm^2 and "a" indicates fractional scatter radiations.

Finally primary and secondary shielding thickness of radiographic rooms was repeatedly calculated according to the NCRP report No.147.

The primary shielding thickness was calculated using the equation (3) and the Fig.1.

Required thickness=NT/Pd^2 (3)

where, N is the total number of patients within a week,

Fig.1.Lead Barrier Thickness(mm)

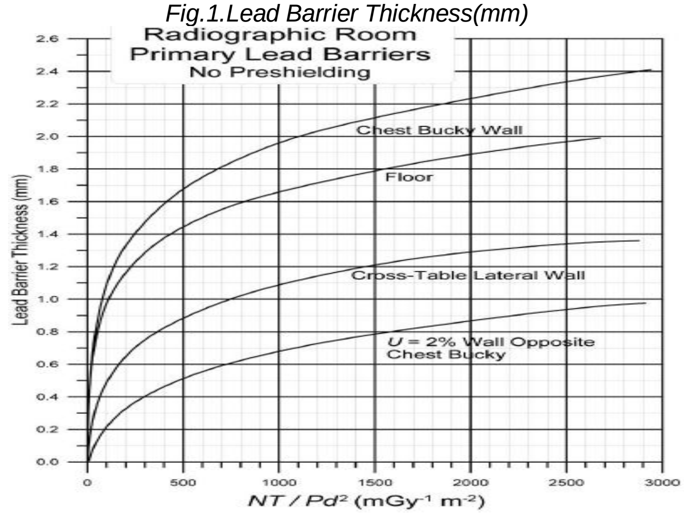

Table 1. The obtained workloads mean in radiographic rooms under study

The name of radiographic center	Aliebneabitaleb Hospital of Zahedan	Buali Hospital of Zahedan	Social Security Hospital of Zahedan	Imaging Medical Center of Zahedan	Nabiakram Hospital of Zahedan	Khatam Hospital of Zahedan
Workload $(\frac{mA.min}{week})$	294	286	685	233	380	1680

T is occupation factor according to the NCRP report No.147, P is the purpose of designing (mGy/week) and d is the distance to the occupied area (m).

The designing of one of the radiographic rooms under study is shown in Fig.2. In this radiographic room, wall 2 is the primary shielding and is used for chest stand radiography. The floor of the room is also regarded as a primary shielding. The ceiling and walls 1, 3 and 4 are secondary shielding, and their thickness is calculated according to secondary shielding thickness.

The results of primary and secondary calculations of radiographic rooms are shown in Tables 2 and 3 according to NCRP reports No.49 and 147. The real thickness of used shielding structure can be seen in the tables according to the equivalent amount of lead and also the knocked lead on the walls. It is worth mentioning that there were no calculations in the rooms located above the ceiling and or under the ceiling in which there is no floor.

Fig. 2.The design of a typical radiographic room under study

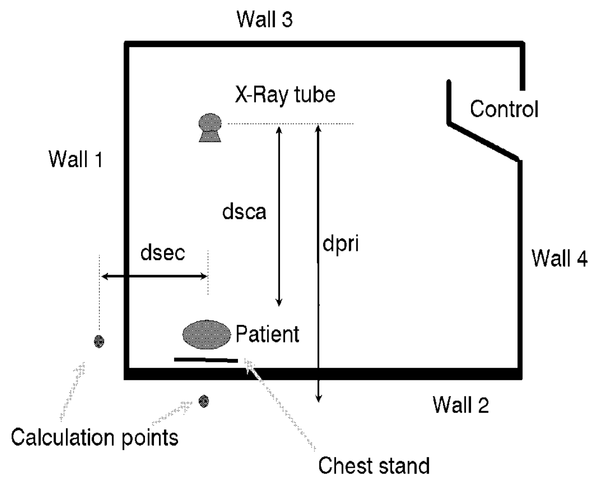

Table 2. The primary and secondary shielding thickness calculated and used in radiographic rooms under study

The name of radiographic center	Type of Barrier	The calculated shielding thickness (mm pb)		The current building shielding thickness (mm pb)	The lead thickness knocked on building shielding (mm pb)
		NCRP No.49	NCRP No.147		
Khatam Hospital	Secondary (wall 1)	1.5	1.5	67	2
	Primary (wall 2)	2.6	2	67	2
	Secondary (wall 3)	1.1	1.1	67	2
	Secondary (wall 4)	0.5	0.5	67	2
Nabiakram Hospital	Secondary (wall 1)	1.8	1.8	67	2
	Primary (wall 2)	1.8	1.3	67	2
	Secondary (wall 3)	0.4	0.4	67	2
	Secondary (wall 4)	1	1	67	2
Imagining medical center	Secondary (wall 1)	0.5	0.5	62	2
	Primary (wall 2)	2	1.8	62	2
	Secondary (wall 3)	0.3	0.3	62	2
	Secondary (wall 4)	1	1	62	2
	Primary (floor)	2.5	1.9	100	0
	Secondary (ceiling)	1	1	100	0

Table 3. The primary and secondary shielding thickness calculated and used in radiographic rooms under study

The name of radiographic center	Type of Barrier	The calculated shielding thickness (mm pb)		The current building shielding thickness (mm pb)	The lead thickness knocked on building shielding (mm pb)
		NCRP No.49	NCRP No.147		
Social Security Hospital	Secondary (wall 1)	0.8	0.8	60	2
	Primary (wall 2)	1.8	1.4	60	2
	Secondary (wall 3)	0.4	0.4	60	2
	Secondary (wall 4)	1	1	60	2
Buali Hospital	Secondary (wall 1)	0.6	0.6	58	2
	Primary (wall 2)	2	1.5	58	2
	Secondary (wall 3)	0.7	0.7	58	2
	Secondary (wall 4)	1	1	58	2
Aliebneabitaleb Hospital	Secondary (wall 1)	0.5	0.5	75	2
	Primary (wall 2)	2	1.2	75	2
	Secondary (wall 3)	1.5	1.5	75	2
	Secondary (wall 4)	0.8	0.8	75	2
	Secondary (ceiling)	0.9	0.9	100	0

Indian Journal of Science and Technology Vol. 4 No. 11 (Nov 2011) ISSN: 0974- 6846

Results and discussion

The workload obtained in radiographic rooms under study shows various amounts of minimal 233 to maximal 1680 in different centers. The reason for this difference is using different mAs factors in different centers and also the high differences of the patients referred to different radiographic centers, and this issue indicates that the amount of workload obtained for a radiographic room can be different to the amount preferred in the NCRP report No.147.

On the other hand, the workload suggested in the NCRP report No.147 is 240 for average radiographic rooms, and 320 for busy radiographic rooms, whereas the concerned workload average of radiographic centers is 593 in this study, which is more than the maximum of determined value through the NRCP report No.147, which this issue can be resulted from this case that the number of radiographic centers of the regarded pre-province is less than the real needs of this pre-province, and this issue by itself increase the radiographic center workload.

As is shown in Table 2 and 3, the secondary shielding thickness is obtained as same in both states whether the NCRP report No.40 or the NRCP report No.147 is used, which this result is obtained in a study conducted by Costa and Coldas (2002), but if the primary shielding thickness of radiographic rooms is calculated according to the NRCP report No.147, the obtained thickness will be less than the calculated according to the NRCP report No.49. This issue indicates that though the radiation workers and general public dose limits has been reduced in the NCRP report No.147 than the NCRP report No.49, in the NCRP report No.147 the previous experiences, especially the results of film badge dosimetry of radiographer's have been regarded, because these results show that radiographic rooms shielding is not merely sufficient according to the NCRP report No.49. It may be the reason why the financial sources and national capitals are wasted in some cases, and this issue has thoroughly been regarded in the NRCP report No.147, in which the reduction of radiation workers and general public dose limits is performed in a way that not only the shielding cost wasting is prevented, but the amounts of required primary shielding is also decreased. It is worth mentioning that other performed studies confirmed this issue (Costa & Coldas, 2002).

Our study also indicates that there has been no calculation about radiographic rooms shielding under study, because the building thickness of the walls, ceiling and floor of radiographic rooms are more higher than that of the needed shielding thickness calculated according to the NCRP reports No.49 and No.147, and not only no rooms needed lead knocking, but the building thickness of radiographic rooms under study provides enough shielding higher than 2mm of knocked lead on the walls, so that lead knocking of these rooms made the financial sources and national capitals wasted.

Conclusion

The shielding calculations of radiographic rooms under study was conducted by estimating the real amount of workload and the NCRP reports No.49 and No.147, and the results obtained indicate that the radiographic rooms, in which their shielding calculations performed by the NCRP report No.49, can easily observe the new determined dose limits in the NRCP report No.147, but the radiographic rooms lead knocking under study, whether according to the report No.49 and whether the report No.147, has not only been unnecessary, but made financial sources wasted. According to the calculations conducted, the amount of lead used in radiographic rooms is nearly 6500 kg , and the only cost of lead used in these 6 radiographic rooms is nearly 9750 $ based on the universal cost of lead which is 1.5$ per kilo, causing heavy economic costs to the community at the macro level.

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