Original paper

Scattered Radiation to The Operators During Fluoroscopy XZS

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Abstract

Background: Since the discovery of the roentgen ray in 1895, radiography and fluoroscopy remained the stanchion of diagnostic radiology for decades. During fluoroscopy procedures the radiation exposure of staff arises due to scattered radiation. The adequacy of shielding for secondary radiation depends on the material and thickness used for this purpose.
Aim of the study: This work studies the secondary shielding for the control booth of fluoroscopy room in AL –Hussaine teaching hospital of Karbala city, Iraq.
Materials and method: By considering the fluoroscopy room design and the radiographic devices profiles used, the clinical total workload per week and total workload per patient have been computed and its distribution according to the most widely used voltages has been determined by recording the actual clinical technical values of maximum ,average and minimum As and the corresponding values of kilovolt peak for 217 patients over five months. As a diagnostic x-ray radiation shielding reference, the National Council on Radiation Protection and Measurements report No.147 (NCRP report No.147) and XRAYBARR computer program have been used to compute the secondarybarrier thicknesses of the control booth of the fluoroscopy room for lead and glass.
Results and discussion: It is found that the total workload per week of NCRP report No.147 is about equal that of calculated for average state and about 1.6 times that of calculated workload for busy state.
Conclusion: The shielding status of control both was quite sufficient ,and about 1 mm of lead was used to shield the front wall and lead glass was used in the shielding of observation window.
Keywords: secondary shielding, fluoroscopy room

Introduction

During fluoroscopic imaging, diagnostic information is carried in the primary beam. These high intensity X-rays are the chief hazard to the patient. Lower energy scattered radiation deviates in all directions from the patient. (1-3). If the x-rays are not shielded such that they only interact with the intended locations, they are potentially hazard to the workers, patients and members of the public(4).The purpose of radiation shielding is to protect workers and the general public from the harmful effects of ionizing radiation (5).

The review of radiation shielding conditions is necessary when the designing assumptions change (6-8).Shielding design of diagnostic imaging facilities has been a subject of several research works during the last years(9-12). These working programs resulted on the publication of recommendations from the National Council on Radiation Protection (NCRP) in US in2005(5) .The National Council on Radiation Protection and measurements report No. 147 (NCRP 147) provides the widely accepted methodology for radiation shielding designing. The new NCRP report,No.147 has released to overcome

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the complexities and problems raised in applying the previous recommendations. Fluoroscopy is frequently used to assist in a wide variety of medical diagnostic and therapeutic procedures, both within and outside of radiology departments. Fluoroscopic equipment capabilities have changed dramatically in recent years. The same fluoroscope may provide a number of operational modes, each of which is tailored to a specific clinical task. Modern fluoroscopic equipment is capable of delivering very high radiation doses during prolonged procedures. There have been reports of serious skin injuries in some patients undergoing certain fluoros-copically guided procedures [13-15]. In this work we present an assessment of the control booth of the fluoroscopy room at AL –Hussaine teaching hospital of Kerbala, Iraq. The shielding review was based on the NCRP report No.147.The calculated total workload per week and workload per patient were compared with that of recommended by NCRP report No.147.

Materials and Method

Determination of workload and clinical workload distribution

In the planning of a radiation installation, the maximum workload and of the number of radiation workers employed should be taken in account. Traditional shielding methods have assumed that a conservatively high total workload per week is performed at a single high operating potential, this assumption ignores the fact that the medical imaging workload is spread over a wide range of operating potentials, The distribution of workload as a function of kVp is important, as the attenuation properties of barriers exhibit strong kVp dependence, hence for radiography room ,to have a curate shielding calculation the accurate value of maximum workload and workload distributions are required. To obtain this purpose the average number of patient sper 36 actual hour work and corresponding technical exposure parameters of average with minimum and maximum mAs where recorded. The most voltages used by the radiographers are 70 kvp for children and 75,77,96 kvp for adults. The values of milliamperage corresponds to 70,75,77,96 kvp vary according to the thickness of the patient and the evaluation of the radiographer. The maximum , minimum and the average mAs, the total workload, total workload per patient, and the most used image field for 217 patients over five months of digital mammography room in AL-Hussaine teaching hospital of Kerbala city is given in table 1 . The mean workload in terms of mA min wk^{-1} was calculated according to NCRP 147[6].The fluoroscopy room contains fluoros copy system type siemens Axion – Iconosor 1000 model-No-3345209x1953 made in Germany. Since the clinical workload distribution gives a better shielding estimate, the average clinical workload distribution for the working voltages of 70,75,77,96 kvp of the studied x-ray room is shown in figure 1.The program; "XRAYBARR" by Douglas J. Simpk in [16] has been used rather than the equations and graphs of NCRP 147. This program, which is able to make calculations for up to 5 distinct X-ray tubes in one installation, utilizes the algebraic and iterative approach mentioned in NCRP No. 147.

Geometry of the room, occupancy and use factor

The geometry of studied room is shown in figure 2.The dimensions of the room are (9.9×6.1) m^2. Only secondary radiation must be considered for radiation protection purposes in fluoroscopy rooms. According to the geometry of the room the control booth is the most important secondary barrier, whereas all other barriers are of minor priority. Area behind wall 1 is an uncontrolled area with the maximally-exposed individual which is a corridor, thereby the occupancy factor is 1/5 .

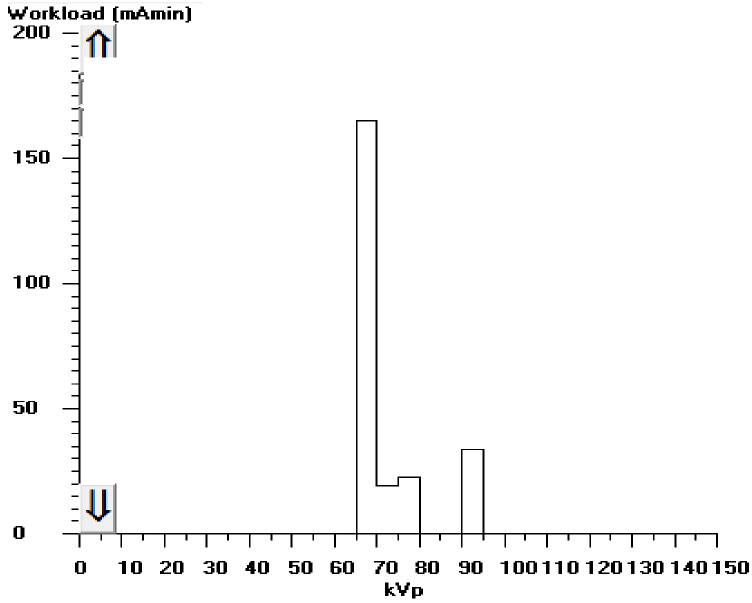

Figure 1. Workload distribution of the Fluoroscopy room

Area behind wall 2 is a gardenhence it is supposed that a given member of the public would spend an average of 1 h week–1 in that area (while the x-ray beam is activated) every week for a year ,so the occupancy factor is 1/40.For wall 3 the adjacent area is an x-ray room this means that the occupancy factor is a unity. The area in front of wall 4 is an X-ray control booth so the occupancy factor according to NCRP 147 is (T=1).since all the walls of the room are considered as secondary barriers ,the use factor for shielding calculations is a unity.

Table 1. Technical data and calculated workload x-ray room studied

kvp	Maximum mAs	Minimum mAs	Average mAs	Average Number of patients per week (N)	Total workload (W_{tot}) mA min wk^{-1}	Total workload per patient (w_{nor})
70	80	70	75	40	240.6	6.01
75	34	30	32			
77	40	36	38			
96	58	54	56			

Secondary barriers calculation

The National Council on Radiation Protection and Measurements (NCRP) report No. 147[(6)]states that Radiation shielding calculations for fluoroscopy systems need only take account of scattered radiation as the primary beam is generally completely intercepted by the image receptor in modern equipment. However, fluoroscopy rooms often have an additional overcouch general tube installed, which may be used. Furthermore, A conservatively safe assumption is that the secondary radiation produced by the fluoroscopy tube is not attenuated by the table, Bucky assembly, or any shielding built into the fluoroscopy system, such as lead drapes.

For secondary barriers calculation using NCRP No.147 ,the air kerma from unshielded secondary radiation Ksec(0) at a distance dsec for N patients per week is

$$Ksec(0)=\frac{k^1_{sec}N}{d^2_{sec}} \quad (1)$$

The unshielded secondary radiation Ksec(0) of fluoroscopy tube should be calculated for control booth for leakage at leakage distancedL=2.5 m and forward/ backscattered radiations at scattered distance ds=3m.

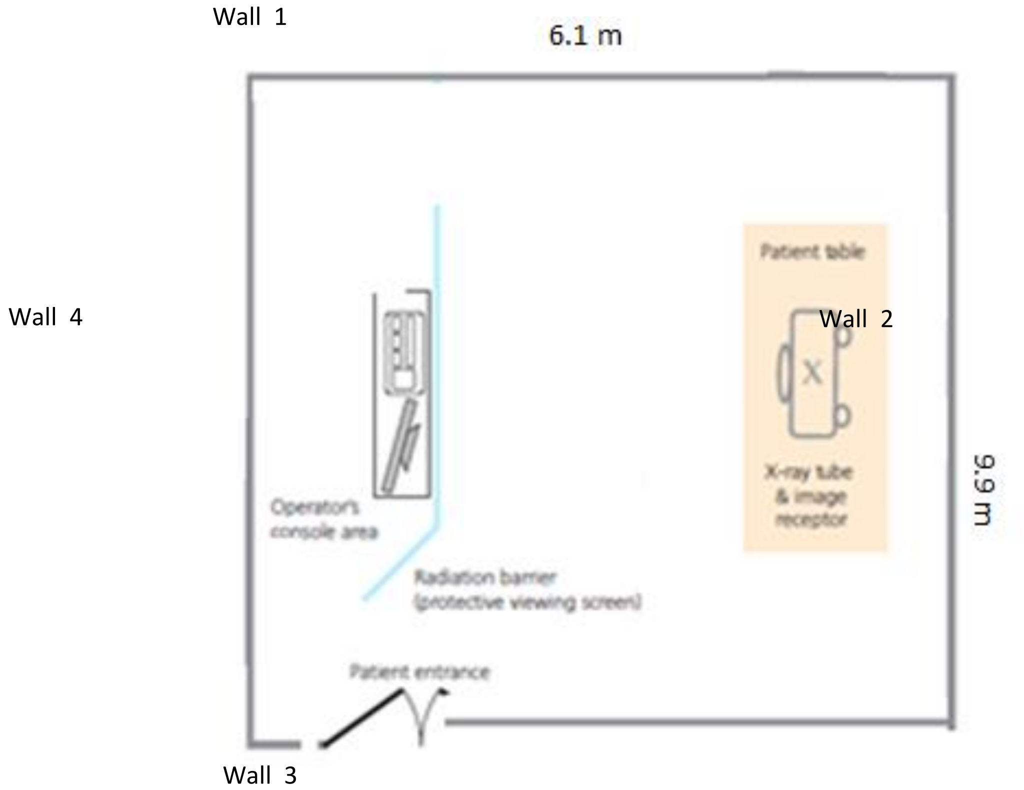

Figure 2. The geometry of fluoroscopy examination room

According toNCRP report No.147 the unshielded air Kerma at 1 m for leakage and forward/backscattered radiations are1.2×10-2 and 4.4 ×10-1 respectively. Hence by applying equation (1) for leakage and forward/backscattered radiations taking into account the above values, the unshielded secondary air kerma from the fluoroscopic tube will be

$$Ksec(0)= \left(\frac{1.2\times10^{-2} mGy\ patient^{-1}}{2.5^2} + \frac{4.4\times10^{-1} mGy\ patient^{-1}}{3^2}\right)\times 36$$

$$Ksec(0)=1.82\ mGy\ week^{-1}$$

Since the control booth is a controlled area, the shielding design goal according to NCRP report No.147 will be

$\frac{p}{T} = \frac{0.01}{1}$=0.1 mGy air kerma

Where p is the shielding design goal, so the required transmission of the wall according to NCRP report No.147 is given by

$$B_{sec}(x_{barrier}) = \frac{\frac{p}{T}}{k_{sec}(0)} \qquad (2)$$

Then the required transmission would be

$B_{sec}(x_{barrier}) = \frac{0.1}{1.82} = 0.054$

By using the NCRP report No.147 curves for transmission of secondary radiation through lead represented by Figure 3 ,the barrier requirement on graph is 0.5 mm.

Since the control booth contains plate glass, one must find the transmission through plate glass.

The required thickness of plate glass according to NCRP report No. 147 which is shown in figure 4 is about 50 mm.

Results and discussion

The workload distribution of the fluoroscopy room in figure 1 shows that the most usable voltage are70,75,77 and 96 kv ,which is used for lumbar cases, kVp should be chosen on the basis of the required contrast of the clinical examination, not on patient size(16).

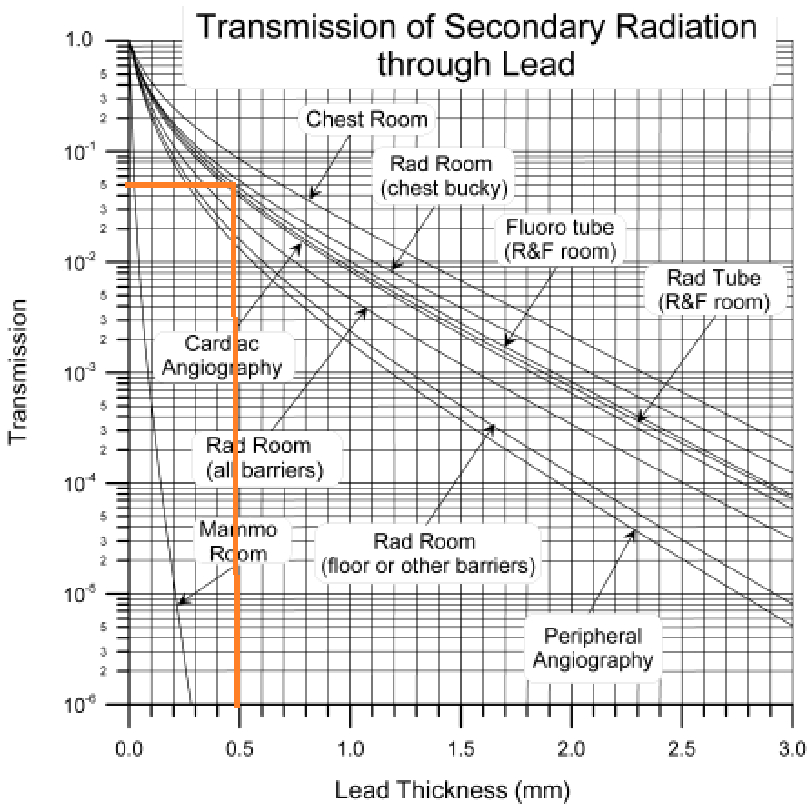

Figure 3. Transmission of secondary radiation through lead

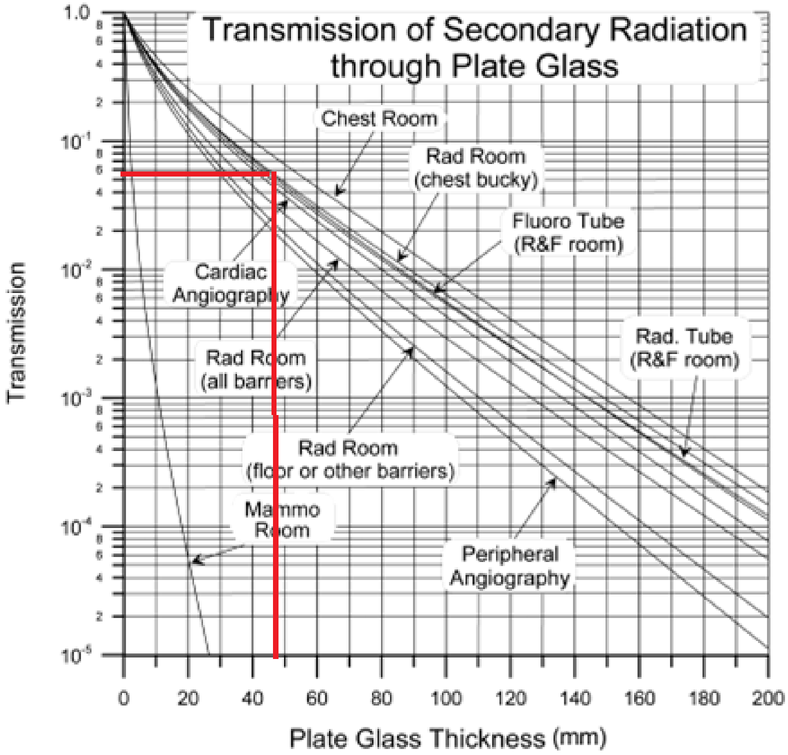

Figure 4. Transmission of secondary radiation through plate glass

According to table 1, the average number of patients per week of the fluoroscopy room is 40 patients which is about twice that of stated by NCRP report No.147[6]for average state and about 13% greater than the busy state as shown in table 2.The total workload per week is of NCRP report No.147 is about equal to that of calculated workload per week for average state and about 1.6 times that of calculated workload for busy state. The main reason of the difference between the workload per week and workload per patients of NCRP report No.147 and that of the calculated is that the workload per week stated by NCRP report No.147 computed for both radiography and fluoroscopy procedures for the same room. The workload computed according to NCRP report No.147 with realistic workload reduce the cost of room shielding for primary barriers[18].For the actual shielding of the control booth, the exist thickness of lead is 1 mm which is twice of the required, and the lead glass thickness is of exactly the same of the required.

Table 2. Comparison of workloads and number of patients obtained from NCRP 147 and the calculated values from the room under study

	Total Workload per patient (mA min/patient)	Number of Patients (per 40 hour week)		Total Workload per week (mA min/week)	
		Average	**Busy**	**Average**	**Busy**
NCRP 147	13	20	30	260	400
Calculated	6.01	40		240.6	

Conclusions

Shielding is an important part of determining the radiation protection requirements during X-ray room design .Hence for radiation protection purposes, it is important to ensure that the shielding provided by the walls, ceiling and floor of an X-ray room are adequate. Shielding must be sufficient to maintain radiation dose to staff and patients in adjoining areas below the regulatory limits[15]. Radiation shielding calculations for fluoroscopy systems need only take account of scattered radiation as the primary beam is generally completely intercepted by the image receptor in modern equipment, So accurate evaluation of the secondary radiation barriers is necessary for assessment of shielding adequacy. In this study the secondary barrier of the fluoroscopy room has been evaluated according to NCRP report No. 147 .It is found that the total workload per week of NCRP report No.147 is equal to that of workload calculated per week for average state and about 1.6 times that of workload calculated for a busy state. The shielding status of control both was quite sufficient ,where about 1 mm of lead was used to shield the front wall and lead glass was used in the shielding of observation window.

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