Secondary shielding for the control booth of the fluoroscopy room at AL –Hussaine teaching hospital of kerbala city,Iraq.

التدريع الثانوي لكشك السيطرة لغرفة الكشف الفلوري لمستشفى الحسين التعليمي في مدينة كربلاء, العراق.

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Abstract

X-ray rooms should be designed to provide flexibleand efficient working areas for different typesof imaging procedure. The adequacy of shielding depends on the material and thickness used for this purpose.This work therefore studies the secondary shieldingfor the control booth of the fluoroscopy room. 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 mAs and the corresponding values of kilovolt peak for 113patients over threemonths. As a diagnostic x-ray radiation shielding reference, the National Council on Radiation Protectionand Measurements report No.147 (NCRP report No.147) and XRAYBARR computer program have been used to compute the secondarybarrier thicknesses of the control boothof the fluoroscopy room forlead and glass. It is found that the total workload per week of NCRP report No.147 is about 4.5 times that of calculated for average state and about 7 times that of calculated workload for busy state. 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.

الخلاصة

ان غرف الأشعة السينية ينبغي أن تصمم بحيث توفر مجالات عمل مرنة وفعالة لأنواع مختلفة من إجراء التصوير.ان كفاية التدريع تعتمد على المادة والسمك المستخدم لهذا الغرضولذلك يدرس هذا العمل التدريع الثانوي لكشك السيطرة لغرفة الكشف الفلوري .باعتبار تصميم غرفة الكشف الفلوري ولمحة عن اجهزة التصوير الشعاعي المستخدمة تم احتساب حمل العمل السريري الكلي في الاسبوع وحمل العمل الكلي لكل مريض كما تم تحديد توزيعها وفقا للفولتيات الاكثر استعمالا من خلال تسجيلالحد الاعلى,متوسطوالحد الادنىلقيم الـ (mAs) وقيم ذروة الكيلو فولت المناظرة لـ (113) مريض على مدى ثلاثة اشهر.كمصدر لتدريع اشعاع الاشعة السينية التشخيصية فأن تقرير المجلس الوطني للحماية من الاشعاعات والمقاييس رقم 147 (NCRP report No.147) وبرنامج الكمبيوتر (XRAYBARR) تم استخدامهما لحساب اسماك الحاجز الثانوي من الرصاص والزجاج لغرفة الكشف الفلوري. لقد وجد ان حمل العمل السريري الكلي في الاسبوع لـ (إنسيآربيرقم 147) بحدود 4.5ضعف حمل العمل السريري لكل اسبوع المحسوبة لحالة المعدل وحوالي 7 ضعف حمل العمل الكلي لكل مريض المحسوبة لحالة مشغولة.ان حالة التدريع لكشك السيطرة كانت كافية تماما وقد استخدم 1ملم من الرصاص لتدريع الجدار الامامي كما استخدم الزجاج المرصص لتدريع شباك المراقبة.

Introduction

By far the greatest manmade exposure to ionizing radiation in the general population is from medical diagnostic procedures involving the use of radiationcontributing about 14% of total worldwide exposurefrom man-made and natural sources[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 researchworks during the last years[9-12] . These working programs resulted on the publication ofrecommendations from the National Council on Radiation Protection (NCRP) in US in2005[6] .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 thecomplexities and problems raised in applyingthe 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 aspecific 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 fluoroscopically guided procedures [13-15]. In this work we present an assessment of the control booth of thefluoroscopy room at AL –Hussaine teaching hospital of kerbala city. 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 exhibitstrong kVp dependence, hence for radiography room ,to have a curate shielding calculation the accurate value of maximumworkload and workload distributionsare required. To obtain this purpose the average number of patientsper 36 actual hour work and correspondingtechnical 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, thetotalworkload, total workload per patient,and the most used image field for 113 patients over three 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 NCRP147[6].The fluoroscopy room contains fluoroscopy system type Siemens Axion – Iconosor1000 model-No-3345209x1953 made in Germany. Since the clinical workload distribution gives a better shielding estimate, the average clinical workload distribution forthe working voltages of 70,75,77,96 kvp of the studied x-ray roomis shown in figure 1.The program; “XRAYBARR” by Douglas J. Simpkin [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 .Area behind wall 2 is a garden hence 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 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.

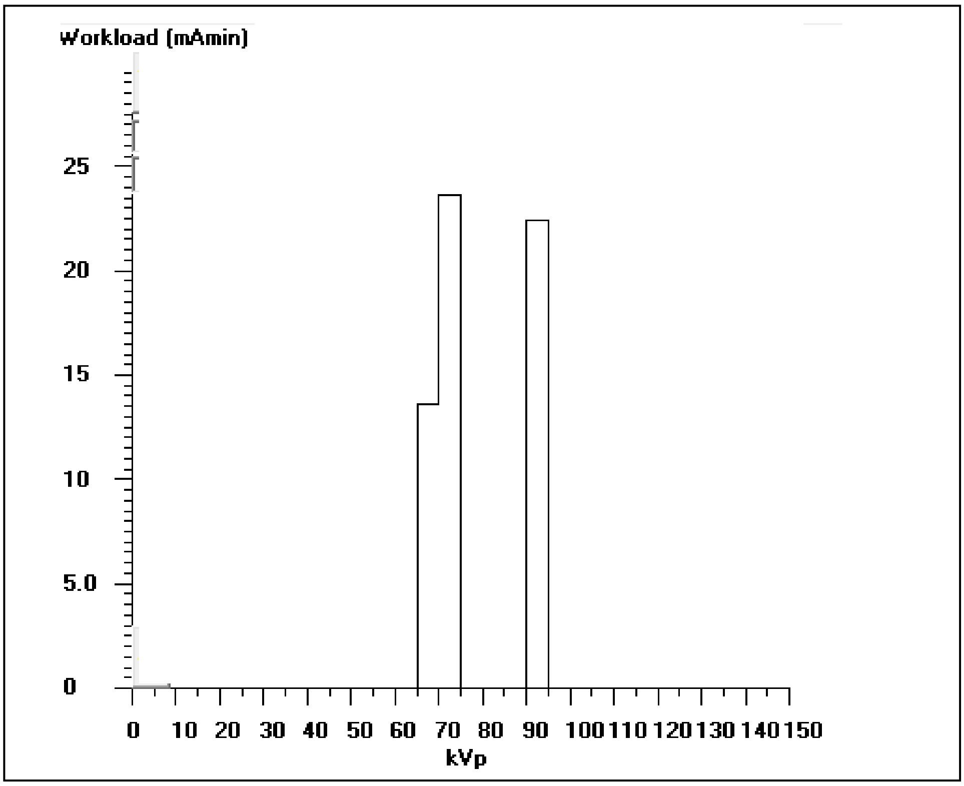

Figure 1.Workload distribution of the fluoroscopy room

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

kvp	Maximum mAs	Minimum mAs	Average mAs	Average Number of patients per week (N) Wall 1	Total workload (W_{tot}) mA min wk^{-1}	Total workload per patient (w_{nor})
70	70	66	68	36	Wall 2 59.65	1.65
75	34	30	32			
77	38	34	36 Wall 3			
96	58	54	56			

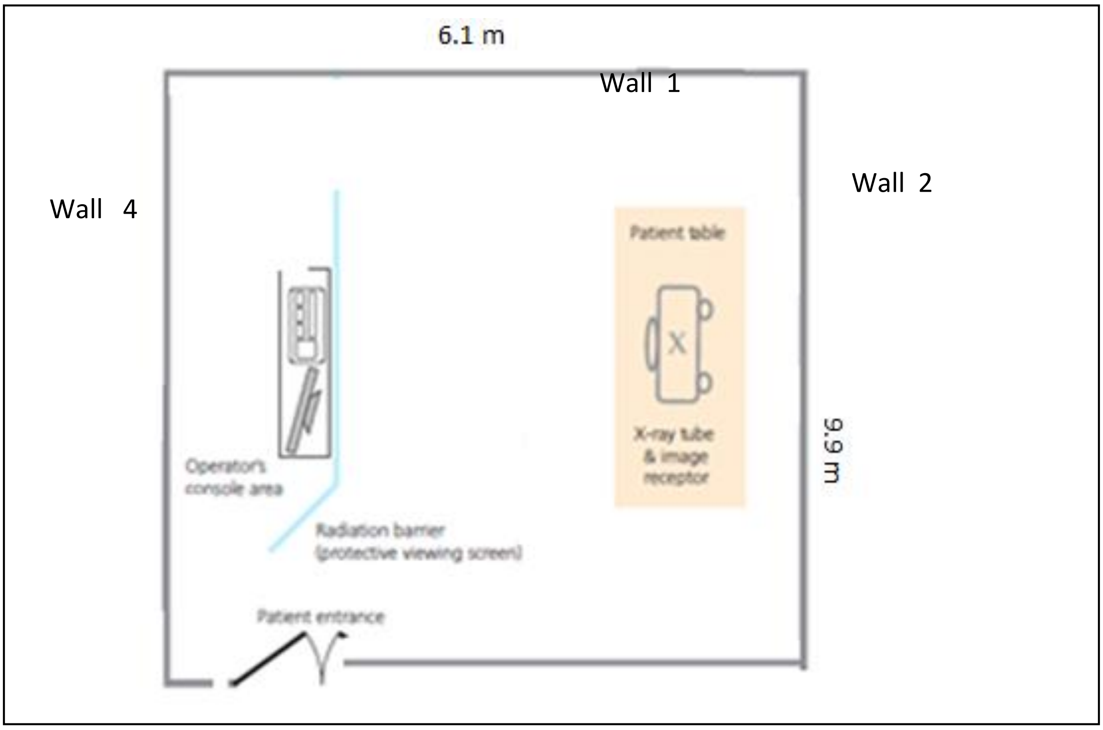

Figure 2.The geometry of the fluoroscopy examination room

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

$$Ksec(0)=\frac{k_{sec}^{1}N}{d_{sec}^{2}} \quad (1)$$

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

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

$$Ksec(0)= \left(\frac{1.2\times10^{-2}mGy\ patient^{-1}}{2.5^2}+\frac{4.4\times10^{-1}mGy\ patient^{-1}}{3^2}\right)\times36$$

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 NCRPreport 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.

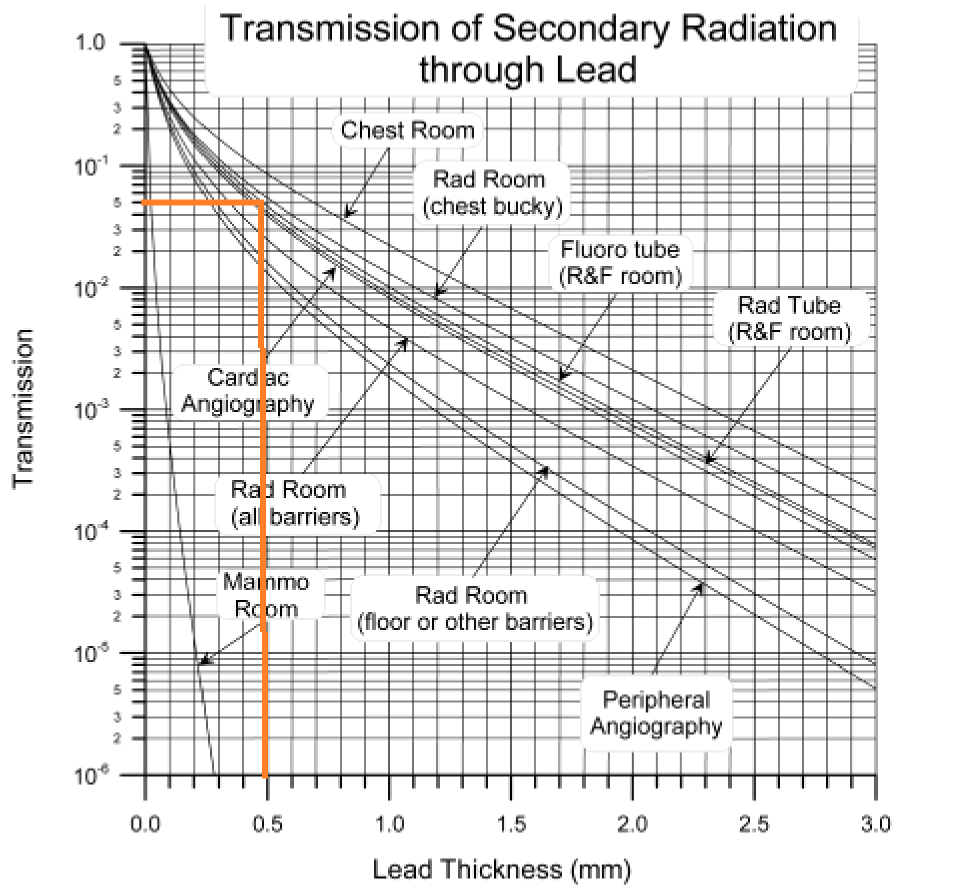

Figure 3.Transmission of secondary radiation through lead

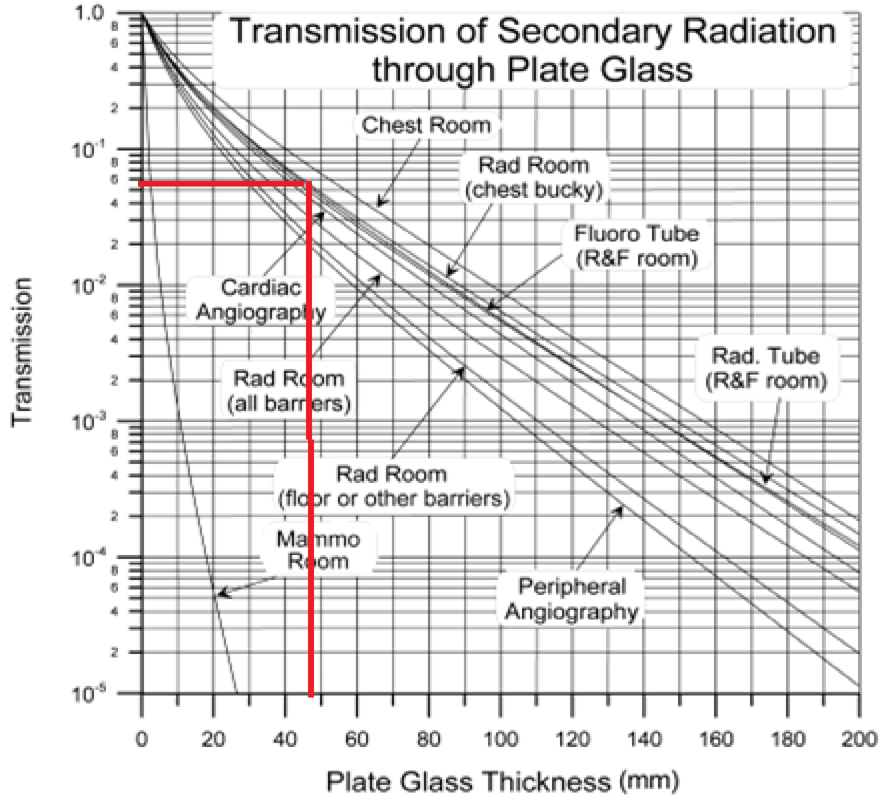

Figure 4. Transmission of secondary radiation through plate glass

Results and discussion

The workload distribution of the fluoroscopy room in figure 1 shows that the most usable voltage are70,75,77 and 96 kvp. ,which is used for lumbar cases. According to table 1, the average number of patients per week of the fluoroscopy room is 36 patients which is about twice that of stated by NCRP report No.147 for average state and about 12% greater than the busy state as shown in table 2.The total workload per week is of NCRP report No.147 is about 4.5 times that of calculated workload per week for average state and about 7 times that of calculated workload for busy state. The main reason of the huge 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 rooms. For the actual shielding of the control booth the exist thickness of lead is 1 mm which is twice that required ,and the lead glass thickness is of exactly the same that 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	1.65	36		59.65	

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 shieldingadequacy. 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 about 4.5 times that of calculated workload per week for average state and about 7 times that of calculated workload for 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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