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Influence of additional filters on radiation dose during chest radiography

***Sadeq Al-Murshedi** **Ali Mohammed Ali**

Al-Zahraa University for Women, College of Health and Medical Technology, Karbala.

*Corresponding Author E-mail: sadeq.almurshedi@alzahraa.edu.iq

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ABSTRACT

The goal of this study was to examine the impact of using additional aluminum (Al) and copper (Cu) filters on radiation dose during the adult chest x-ray examination. Adult chest phantoms without and with different slabs of animal fat were used for simulating underweight, overweight, and obese patients, respectively. Phantoms were examined without and with various levels of extra Al and Cu filtering over a range of exposure parameters. A dose area product (DAP) meter was used to measure the radiation dose. Results demonstrated that radiation doses were significantly reduced ($p=0.001$) when applying extra filters compared with no filters for all of the different phantom sizes. The highest reduction in radiation dosage was 38, 41, and 42 percent for underweight, overweight, and obese phantom size, respectively, by 1mm Al+0.2mm Cu. In conclusion, the use of extra filters in chest x-ray imaging provides an optimal dose reduction choice regardless of the thickness of the chest region to be radiographed.

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تأثير الفلاتر الإضافية على جرعة الإشعاع أثناء التصوير الشعاعي للصدر

صادق حليم المرشدي **علي محمد علي**

جامعة الزهراء للبنات كلية التقنيات الصحية والطبية كربلاء العراق

الكلمات المفتاحية:

الفلاتر
تصوير الصدر بالأشعة
جرعة الإشعاع

الـــخُــلاصـــة

كان الهدف من هذه الدراسة هو فحص تأثير استخدام فلاتر إضافية من الألومنيوم (*Al*) والنحاس (*Cu*) على جرعة الإشعاع أثناء فحص الصدر بالأشعة السينية لاعمار للبالغين. تم استخدام دمية تصوير طبي لمنطقة الصدر لاعمار البالغين بدون ومع استخدام ألواح مختلفة من الدهون الحيوانية لمحاكاة مرضى نقص الوزن ، وزيادة الوزن ، والسمنة ، على التوالي. تم تصوير دمية التصوير الطبي بدون ومع مستويات مختلفة من فلاتر الترشيح الاضافية من الألومنيوم (*Al*) والنحاس (*Cu*) على مجموعة من معاملات التعرض. تم استخدام مقياس منطقة الجرعة (*DAP*) لقياس جرعة الإشعاع. أظهرت النتائج أن جرعات الإشعاع انخفضت

بشكل كبير ($p = 0.001$) عند تطبيق فلاتر إضافية مقارنة مع عدم وجود فلاتر لجميع الأحجام المختلفة. كان أعلى انخفاض مئوي في جرعة الإشعاع ٣٨ و ٤١ و ٤٢ لنقص الوزن وزيادة الوزن والحجم الوهمي للسمنة ، على التوالي ، بمقدار (١ مم $Al + 0.2$ مم) نحاس.
نستنتج انه يوفر استخدام الفلاتر الإضافية في تصوير الصدر بالأشعة السينية خيارًا مثاليًا لتخفيض الجرعة بغض النظر عن سمك منطقة الصدر المراد تصويرها بالأشعة.

1. INTRODUCTION

The exposure of ionising radiation during x-ray imaging with excessive amount can lead to serious biological and pathological costs. In addition, the risk from ionizing radiation is proportionaly related to the amount of radiation dose received by the patients. Therefore, there should be organized measures to regulate and quantify the amount of radiation nessesary for obtaining x-ray images [1]. During x-ray radiography, a there are many conditions that can control the total radiational risk that a patient is expected to perceive. Those conditions include the type of the radiological information needed, imaging system, patient size and the skillsets of the radiography practitioners. The are increased number radiographic imaging techniques in the healthcare field, such increase would create extra challenges to the controlling of the radiotion risks to the patient [2].

On the other hand, The generation of an image of adequate quality in order to answer the clinical examination query is a necessary technical focus of any X-ray examination to keep acceptable radiographic quality with reasonably low radiation doses This is balanced by the need to avoid excessive ionizing x-ray radiation exposure to the patient during radiographic examination [3].

One fundamental goal of national legislation is to determine proper exposure factors (acquisition factors) conditions that provide sufficient image quality while using the least amount of radiation possible. Different studies utilized filtration effect on dose reductions when imaging pelvic areas [1,4]. The employment of extra filters is one of the methods utilized to maintain a balance between dose and image quality [5–7]. The reason for this is that it reduces the radiation with low energy from the X-ray spectrum, which does not boost image quality but rather raises the patient's radiation exposure [5].

In this study, we evaluated the effect of using extra filters on radiation exposure for different body part thicknesses when performing the adult chest x-ray examination.

2. Materials and Methods

Lungman adult chest phantom without and with 6 cm and 8 cm slabs of animal fat (Figure 1) was used for simulating underweight (20 cm thick), overweight (26 cm thick), and obese patients (28 cm thick), respectively. Phantom images were captured without and with extra aluminum (Al) and copper (Cu) filters (2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm), the source to image distance (SID) was 180 cm, and the kVp and mA values are shown in Table 1.

The phantom was imaged using a Wolverson X-ray Ltd DR system (Willenhall, West Midlands, UK). Inside the erect wall, Bucky, a fixed anti-scatter radiation grid (10:1, 40 lines/cm frequency) was installed. 3 mm of Al was used for the overall intrinsic X-ray beam filtering. To minimize random error, the radiation dose reported from the Dose Area Product (DAP) was measured three times for each exposure.

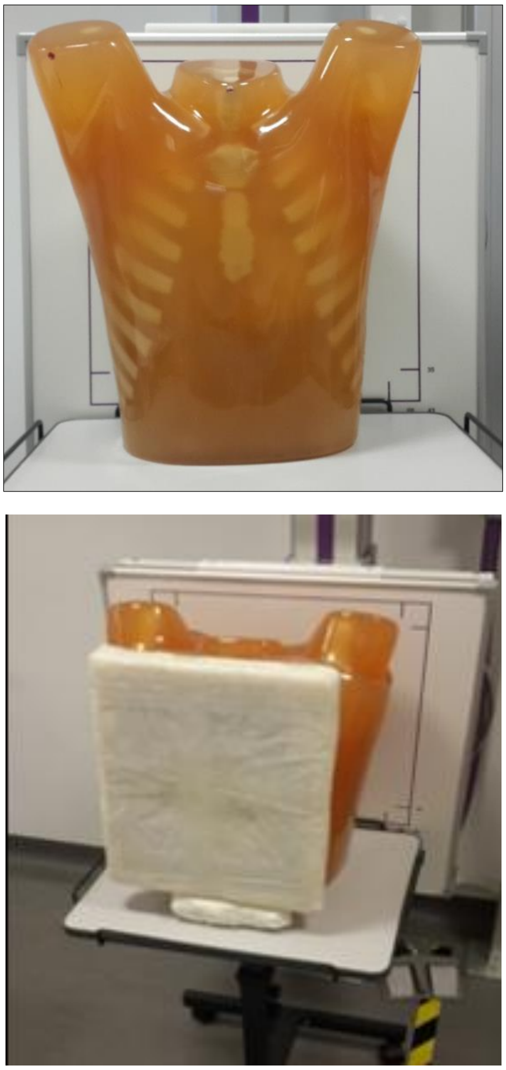

Figure 1: Lungman adult chest phantom and animal fat layers.

Table 1: Exposure parameters employed for imaging the three phantom thicknesses.

kVp/mAs	Phantom Thicknesses		
	20 cm	26 cm	28 cm
80	4.6	14	19.8
85	3.6	10.8	15.1
90	2.8	8.2	11.1
95	2.5	6.4	8.6
100	2.1	5.4	7.2
105	1.8	4.6	6.1
110	1.8	3.9	5
115	1.4	3.6	4.6
120	1.4	3.2	4.3
125	1.4	2.8	3.9
130	1	2.5	3.6

Statistical analysis

The mean and standard deviation (SD) values of the radiation dose were computed for each phantom size and amount of added filters. The Shapiro-Wilk test was employed to investigate the data's normality distribution and all data were found to be normally distributed. A repeated measure ANOVA test was used to compare the radiation dose values of the extra filtration (2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm) with those of no extra filtration over the three phantom thicknesses. SPSS software was used for statistical analysis.

Table 2: Mean (SD) radiation dose values for all applied filters across the three phantom thicknesses.

Thicknesses of a phantom (cm)	Extra filters (mm)			
	0	2Al	1Al+0.1Cu	1Al+0.2 Cu
	Mean value of DAP (±SD) (μGy.cm^2)			
20	45 (9.6)	39 (8.5)	34 (6.9)	30 (6.2)
26	129 (39.6)	111 (33.1)	96 (28.2)	84 (24.5)
28	176(58.6)	150 (49.1)	129 (40.9)	113 (35.4)

3. Results and Discussion

Radiation dosage data for various additional filters (0, 2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm) across the three phantom thicknesses are shown in (**Figs. 2-4**). **Table 2** shows the mean (SD) radiation dosage values for the different phantom thicknesses (20, 26 and 28 cm) for the various additional filters (0, 2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm). According to the Repeated measure ANOVA test, additional filters (2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm) reduced radiation dosage significantly (p=0.001) in all three phantom thicknesses.

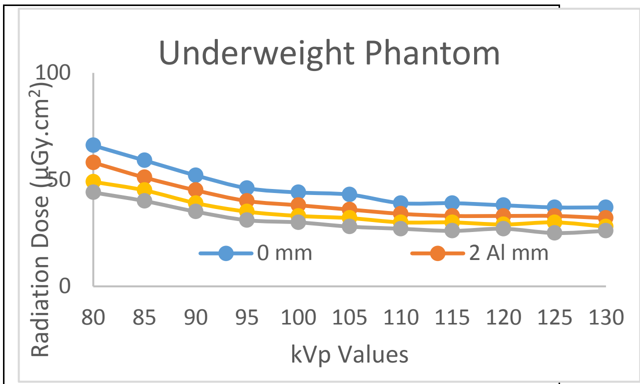

Figure 2: Radiation dosage values (underweight size phantom) for 0, 2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm extra filters.

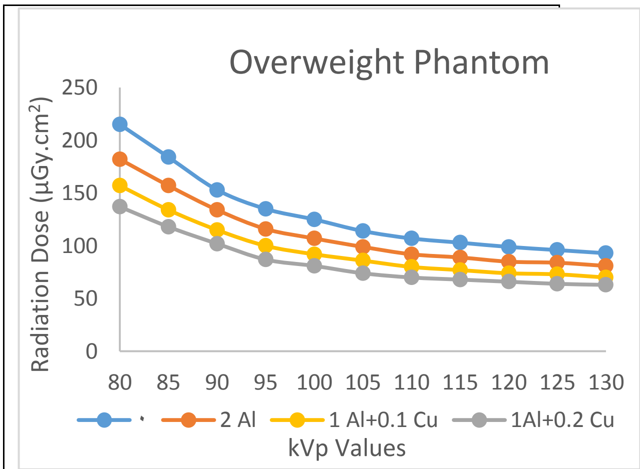

Figure 3: Radiation dosage values (overweight size phantom) for 0, 2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm extra filters.

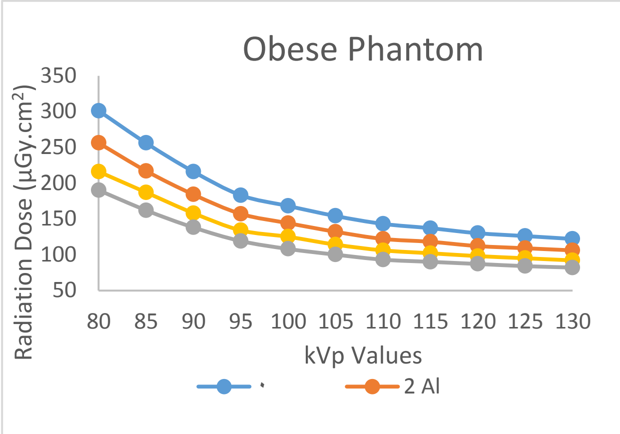

Figure 4: Radiation dosage values (obese size phantom) for 0, 2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm extra filters.

In our current study, we demonstrated that using extra filters (2Al, 1Al+0.1 Cu, and 1Al+0.2 Cu mm) can reduce radiation exposure during chest x-ray imaging for different phantom sizes. The greatest decrease in radiation dosage was lowered by 1mm Al+0.2mm Cu by 38, 41, and 42 percent for 20, 26, and 28 cm phantom thicknesses, respectively. Our findings agreed with previous research on the effect of extra filters on radiation dosage, despite the fact that those studies used varying degrees of extra filters, techniques, phantom types, and sizes [8,9] [5,7].

The impact of added filters on image quality evaluation was not included in our study, which was one of its limitations; however, future research could investigate the impact of added filters on visual image quality utilizing the Lungman adult chest phantom. Furthermore, future works could demonstrate the effect of extra filtration on the physical measure of low contrast detail detection, which was extensively utilized as a tool for image quality evaluation[10–13] and had a strong relationship with visual image quality evaluation [14–16].

4. Conclusions

When performing chest X-ray imaging for varied body sizes, extra filters can be used to reduce radiation exposure and it is an efficient approach to reduce patient dose regardless of the thickness of the chest region to be radiographed.

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