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Effect of Filter and Thickness Variation on Entrance Skin Exposure (ESE) Values of Thorax Organs

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Abstract

Research has been conducted on the effect of variations and thickness of filters on the value of Entrance Skin Exposure (ESE) with the use of phantoms in thorax examination with the aim of knowing the effect of using variations and thickness of Al, Cu and Pb filters on ESE values using thorax examination phantoms and to determine the effect of variations in irradiation time-current on the use of variations and thickness of Al, Cu and Pb filters on ESE values using thorax examination phantoms. The results showed that the thicker the filter used, the ESE value obtained decreased, and vice versa. While the results obtained for the irradiation time-current are the greater the time-current used, the ESE value obtained increases, and vice versa. Filters that enter the tolerance limit of thorax examination are Aluminum (Al) filters with a thickness of 1.5 mm and a time-current of 8 mAs, which is 0.089594 mGy. This is influenced by several factors including the thickness of the filter used, the irradiation time-current performed and the density of the filter.

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1. INTRODUCTION

Technological advancements are currently growing rapidly. One of the developments is in the way medical experts treat patients in the use of X-rays. In diagnostic examinations, it can be used to provide supporting data to doctors in diagnosing diseases suffered by patients in detail. Besides being used in medical media, X-rays are also used as radiotherapy [1]. X-rays were discovered by a physicist named Wilhelm Conrad Rontgen in 1845-1923. The appearance of greenish glow at the end of the tube whose position is opposite to the cathode is an interesting phenomenon and the attention of researchers. The process of working with a cathode ray tube in the laboratory of the University of Wurzburg, Rontgen was interested in his observations, namely the presence of a greenish flame on the wall until the light waves emitted by the glass wall of the tube were known to be rays [2].

X-rays themselves are defined as electromagnetic radiation that delivers energy in the form of packages called photons, because X-rays have a very large penetrating power, so X-rays have a function as a phantom radiation dose meter [3]. Phantom is a modeling object shaped like a human object where this phantom is used in the field of radiology both in terms of radio diagnostics and radiotherapy, namely as a realistic evaluation of image quality [4]. X-ray aircraft basically consists of the following components, namely the X-ray generator tube, control console. X-ray tube is a hollow tube in which X-rays are produced. The generator on the X-ray aircraft is a device that delivers electrical power to the X-ray tube. X-ray tubes require electrical energy used to heat electrons from the filament and accelerate electrical energy to heat electrons from the cathode to the anode [5]. The exposure factor is a factor that can determine the quality and quantity affected by the irradiation of X-ray radiation in the manufacture required in the radiograph image. The exposure factors include tube voltage (kV), tube current (mA) and exposure time (ms) [6]. Kilo Volt (kV) is the voltage value that affects the quality of X-rays in penetrating the object, while milli Ampere (mA) is the tube current that affects the quantity of X-rays produced by the X-ray tube and second (s) is the tube voltage irradiation time that works during the X-ray production process [7] According to [8], said that in the use of mA, s and kV for patient examination, the dose received will be reduced, if the use of kV used is high and also offset by a decrease in the value of mA and s. Meanwhile, for article 36 paragraph 2 of BAPETEN regulation No. 8 of 2011, explains about optimizing radiation safety and protection must be pursued in order to achieve diagnostic goals in patients in receiving the lowest possible dose [9].

Thorax examination is an examination performed on the internal organs in patients using X-rays as a penetrating power in irradiating the internal organs of the body. Thorax examination is a very important examination. Lung examination without X-ray examination is currently considered incomplete. The current rapid progress in showing the internal organs of the body, namely the heart, lungs, respiratory tract, and blood vessels, is by using thorax x-rays [10]. Measurement of ESE in thorax examination with exposure to the X-ray axis in the measurement there is a point that is exposed to radiation so that in this case it has milliroentgen units. The use of X-ray aircraft voltage is carried out by adjusting the examination of the organ to be examined and the exposure factor so that this is very influential in relation to the large value of ESE X-ray intensity that will be measured and for ESE measurements themselves are carried out with free-in-air techniques. The entrance dose surface (Table 1) is an important parameter for assessing the dose received by patients in radiographic exposure [11].

Table 1 ESE tolerance values for organs of examination [5]

Examination	ESE (mGy)
Cranium	0.348-0.522
Thorax (PA)	0.087-0.26
Thorax (Lateral)	0.435-0.87
Abdomen	0,87-3.5
Columna Vertebralis (Lateral)	4.35-13.04
Pelvis	2.17-4.35

According to the IAEA (International Atomic Energy Agency) Technical Report Series No. 457 (2007), the value range between 1.24-1.67 is the Back-Scatter Factor (BSF) value for radiography. BSF value generally used in patients is 1.35. Research conducted by Litasova et al., states that a combination of 1-1.5 mm filter thickness is one of the exposure factors used in head examinations [12]. The combination of Al and Zn with the use of a filter thickness of 1.5 mm and for the combination of Al filters with Galvalume produces a limit value of mGy which is 0.348-0.522 mGy. For the thickness of the filter combination between 1-2 mm is below the tolerance limit on the combination of SS filters with Galvalume, Zn, Al, Cu with Al, Cu Galvalume and Zn.

Other research conducted by Pamungkas, states that using a thickness of 0.2 mm and 0.3 mm for Cu filter variations and 0.25 mm and 0.50 mm for Zn filters in the examination of thorax organs is within the tolerance limit (0.0887-0.87) mGy, while with a thickness of 0.75 mm in the Zn filter variation and for a thickness of 0.4 mm for the Cu filter variation is within the tolerance limit (0.348-0.522) mGy for cranium examination [13]. The Al filter thickness of 3.03 ± 0.28 mm results from half the ESE value with a voltage of 90 kV. For values of 0.135 ± 0.04 mm for Cu filters and 0.22 ± 0.05 mm for Zn filters, it is equivalent to using Al filters.

Based on several studies on the type of filter and filter thickness, it is necessary to conduct research on the effect of filter variation and thickness on the value of entrance skin exposure (ESE) with the use of phantoms in thorax examination. This study aims to determine the effect of the use of variations and thickness of Al, Cu and Pb filters on the value of ESE using a thorax examination phantom and to determine the effect of irradiation time-current variations on the value of ESE using a thorax examination phantom. To determine the effect of variations in irradiation time-current on the use of variations and thickness of Al, Cu and Pb filters on the value of ESE using a thorax examination phantom.

2. RESEARCH METHOD

This research was conducted from December 2021 to July 2022 at the Makassar Health Facility Safety Center (BPFK) using a Siemens brand mobile X-ray aircraft, detector, waterpass, cabinet (Raysafe), PMMA / Acrylic phantom, ruler, screw micrometer, meter, the filters used are Aluminum (Al), Copper (Cu) and Lead (Pb).

Before the research measurements were taken, the first thing to do was to record all the specifications of the mobile X-ray aircraft. Prepare tools and materials. Placing the PMMA/acrylic phantom parallel to the collimator on the mobile X-ray device. Measuring the thickness of the filter types namely Al, Cu and Pb with a thickness of 1.5 mm and 2 mm respectively using a screw micrometer. Placing the filters according to the filter type and thickness variations that have been measured. First for Aluminum filters with a thickness of 1.5 mm will be placed on the phantom and the detector will be placed on the filter. PMMA / acrylic phantom, filter and detector will be aligned perpendicularly on the axis or pointing to the X-ray tube, then adjust the tube voltage (kV) and irradiation time-current (mAs) by pressing the kV and mAs setting buttons on the mobile X-ray aircraft operation panel, rearrange the radiation field by pressing the button on the collimator then turn the knob to adjust the object area which is the area to be irradiated 20 cm × 20 cm, then set the Source Skin Distance (SSD) 100 cm using a meter, After everything is set up the operation panel will turn on and the buzzer will sound. Then press the exposure button on the handswitch to generate X-rays. The buzzer will sound when the X-ray generation is complete. Perform exposure, record the results of the Extrance skin exposure (ESE) value listed on the raysafe brand cabinet. After that, repeat the same steps for Cu and Pb filter types with thicknesses of 1.5 mm and 2 mm respectively with exposure factors of 5 mAs, 6.4 mAs and 8 mAs. Tested 5 times so that each data generated is more accurate. The research scheme can be seen in Figure 1.

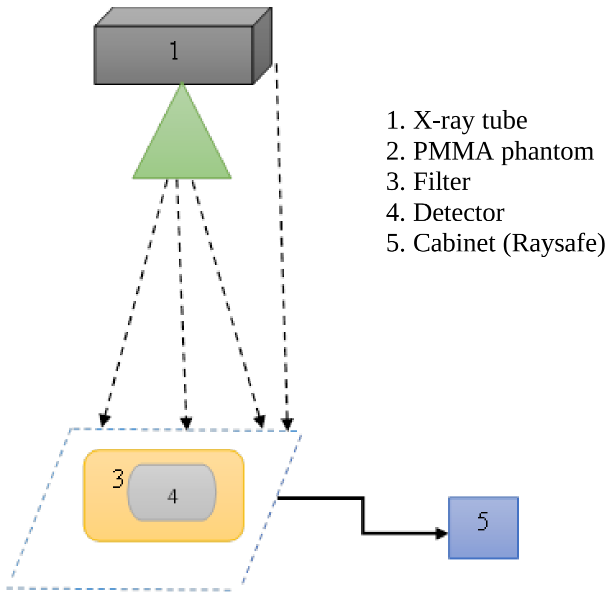

Figure 1. Schematic of Entrance Skin exposure (ESE) measurement

3. RESULTS AND DISCUSSION

In this research using Aluminum (Al), Copper (Cu) and Lead (Pb) filter types with variations in the thickness of each filter which is 1.5 mm and 2 mm and variations in irradiation time-current of 5 mAs, 6.4 mAs and 8 mAs on the Entrance Skin Exposure (ESE) value using PMMA / acrylic phantom on thorax examination. PMMA/acrylic phantom in thorax examination serves as an exposed object. When irradiating X-rays to the PMMA / acrylic phantom (thorax examination), the part of the phantom that first receives X-ray radiation is the outermost part of the skin. So that the dose on the surface of the phantom receives the maximum dose. The dose received on the surface of the acrylic phantom is called Entrance skin Exposure (ESE). Furthermore, for each type of filter, variations in the filter as seen in Table 2 which is the measurement of the average ESE value in units (mGy) using filters (Al), (Cu) and (Pb) with a thickness of 1.5 mm and 2 mm respectively on the use of PMMA / acrylic phantoms with a fixed voltage value of 50 kV and irradiation time-current variations of 5 mAs, 6.4 mAs and 8 mAs

Table 2 Measurement of ESE mean in units (mGy) on the type and thickness of the filter against the ESE value on the thorax examination phantom with a fixed voltage, namely: 50 kV.

No	Current-Time (mAs)	Filter Type	Filter Thickness (mm)	Measured Value (μGy)					ESE Mean (mGy)
				1	2	3	4	5	
1.	5 mAs	Al	1.5	55.97	56.10	56.30	55.97	56.24	5.61×10^{-2}
			2	48.12	48.16	48.27	48.09	48.12	4.82×10^{-2}
		Cu	1.5	87	84	87	86	86	8.60×10^{-5}
			2	19	22	20	24	28	2.26×10^{-5}
		Pb	1.5	31	26	26	32	30	2.90×10^{-5}
			2	17	18	12	18	20	1.70×10^{-5}
2.	6 mAs	Al	1.5	71.80	71.89	71.75	71.79	71.93	7.18×10^{-2}
			2	61.72	61.86	61.80	61.64	61.78	6.17×10^{-2}
		Cu	1.5	121	113	121	118	111	1.17×10^{-4}
			2	18	22	20	21	23	3.26×10^{-5}
		Pb	1.5	33	45	41	32	38	3.78×10^{-5}
			2	35	34	32	27	35	2.08×10^{-5}
3.	8 mAs	Al	1.5	89.54	89.66	89.42	89.68	89.67	8.96×10^{-2}
			2	76.80	77.04	77.16	76.94	76.99	7.70×10^{-2}
		Cu	1.5	136	139	137	140	131	1.37×10^{-4}
			2	23	18	23	21	22	3.52×10^{-5}
		Pb	1.5	40	39	44	37	46	4.12×10^{-5}
			2	35	38	31	31	41	2.14×10^{-5}

According to table 1, five times the ESE value was measured by averaging the five values obtained which aims to produce a more accurate ESE value using a fixed voltage of 50 kV with variations in irradiation time-current of 5 mAs, 6.4 mAs and 8 mAs. Table 2 shows that the results of the Entrance Skin Exposure (ESE) value using PMMA / acrylic phantom (thorax examination) on the type and thickness of the filter with a fixed input voltage of 50 kV and irradiation time-current of 5 mAs, obtained a very far difference in ESE value, namely for Al filters with a thickness of 1. 5 mm and 2 mm produced ESE values of 5.61 × 10-2 mGy and 4.82 × 10-2 mGy, for Cu with a thickness of 1.5 mm and 2 mm produced ESE values of 8.60 × 10-5 mGy and 2.26 × 10-5 mGy, for Pb with a thickness of 1.5 mm and 2 mm produced ESE values of 2.90 × 10-5 mGy and 1.70 × 10-5 mGy. For the irradiation time-current of 6.4 mAs, the results obtained include for the Al filter with a thickness of 1.5 mm and 2 mm of 7.18 × 10-2 mGy and 6.18 × 10-2 mGy, for Cu with a thickness of 1.5 mm and 2 mm the ESE values of 1.17 ×10-4 mGy and 3.26 × 10-5 mGy, and for Pb with a thickness of 1.5 mm and 2 mm the average ESE values of 3.78 × 10-5 mGy and 2.08 × 10-5 mGy. While the filter type and filter thickness with irradiation time-current of 8 mAs, for Al filter with thickness of 1.5 mm and 2 mm, the ESE values of 8.96 × 10-2 mGy and 7.70 × 10-2 mGy were generated, for Cu with thickness of 1.5 mm and 2 mm, the average ESE values of 1.37 × 10-4 and 3.52 × 10-5 mGy were generated, for Pb with thickness of 1.5 mm and 2 mm, the ESE values of 4.12 × 10-5 mGy and 2.14 × 10-5 mGy were generated.

Based on Figure 2, it can be seen that the strong setting of irradiation time-current to the ESE value shows that the greater the irradiation time-current given, the ESE value obtained will also increase. The results of this study are in accordance with those obtained by [14] which shows that the effect of the irradiation time-current setting is very instrumental to the size of the increase in radiation exposure intensity. The greater the irradiation time-current setting, the greater the increase in radiation exposure intensity.

From Figure 2, it can also be seen that the variation of filter thickness affects the ESE value obtained. The thicker the filter used, the smaller the ESE value obtained. This is in accordance with research conducted by [13] which found that the thicker the filter used, the greater the absorption of X-ray beams, so that the ESE value will decrease.

In this research, the ESE value obtained in accordance with the tolerance limit is by using an Al filter at a fixed voltage value of 50 kV and a time-current of 8 mAs, which is 0.089594 mGy. These results are in accordance with research conducted by [5], which states that the ESE tolerance value for thorax examination is 0.087-0.87 mGy. So that the filter used (in this case using an Al filter with a thickness of 1.5 mm) is safe for use in thorax examinations.The same thing also happened in the research conducted by Azam and Setiawati, which found that the ESE value with the chest examination factor (lateral) was within the tolerance limit of 0.435-0.87 mGy using Al filters with a thickness of 1-3.5 mm [15].

Measurements made with each type of filter, other than using an Al filter at a thickness of 1.5 mm with an irradiation time-current of 8 mAs, did not fall within the range of thorax organ examination values. This is due to several factors including the thickness of the filter used, the irradiation time-current carried out and the density of the filter. As previously described, the Al filter density of 2.7 g/cm3 has the smallest density compared to other filters, so that the absorption of the X-ray beam is the least, which results in the ESE value obtained being large compared to other filters [15].

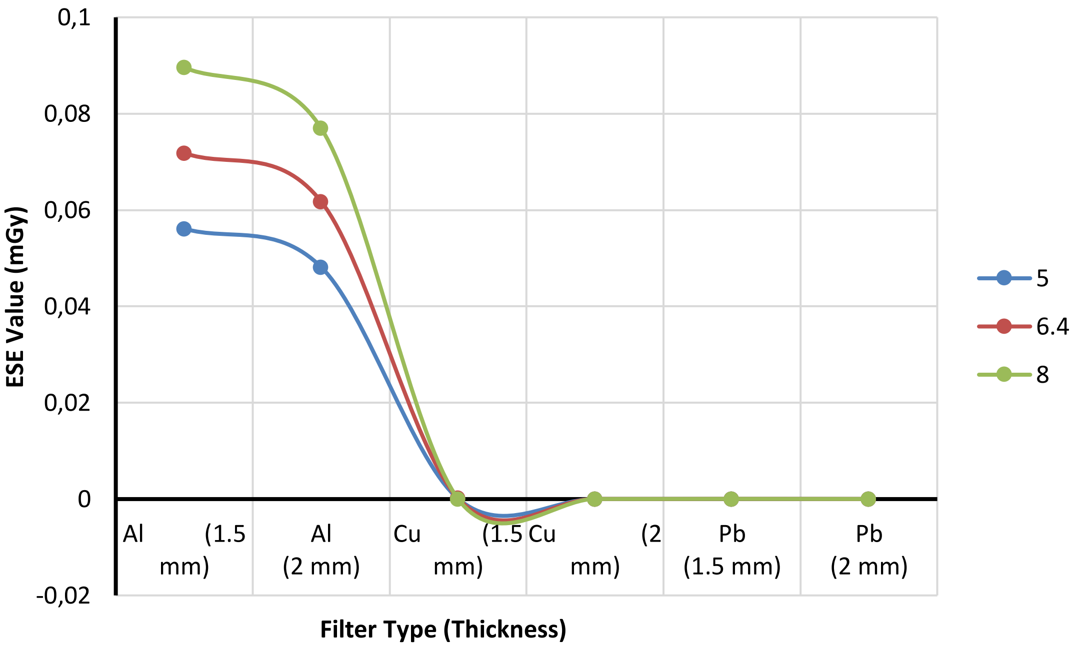

Figure 2. Relationship between time-current 5 mAs, 6,4 mAs, and 8 mAs of filter type Al (1,5 mm), Al (2 mm), Cu (1,5 mm), Cu (2 mm), Pb (1,5 mm), and Pb (2 mm) with ESE value

4. CONCLUSION

The effect of using filter variations and filter thicknesses of Al, Cu and Pb on ESE values using PMMA/Acrylic phantoms in thorax examinations is that the thicker the type of filter used, the ESE value in thorax examinations obtained decreases, and vice versa the thinner the type of filter used, the ESE value will increase and the relationship between time-current variations on filter types and ESE values with the thickness of the filter used is that the greater the time-current used, the ESE value in thorax examinations obtained increases, and vice versa the smaller the time-current used, the ESE value obtained decreases.

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REFERENCES

[1] S. Masrochah, 'Pengaruh peningkatan tegangan Tabung Sinar X terhadap Kontras Radiografi dan laju Dosis Radiasi'. FMIPA UNDIP, 2000.

[2] M. Akhadi, *Sinar-X Menjawab Masalah Kesehatan*. Deepublish, 2020.

[3] F. Suyatno, 'Seminar Nasional IV SDM Teknologi Nuklir Aplikasi Radiasi Sinar-X Di Bidang Kedokteran Untuk Menunjang Kesehatan Masyarakat Ferry Suyatno', 2008.

[4] U. Pratiwi, 'Application of Phantom Detail Image Analysis with Digital to Matric Data Conversion Method to Increase Image Contrast Using Film Imaging Plate.', 2005.

[5] J. T. Bushberg, 'The Essential Physics of Medical Imaging, Third Edition.', *Medical Physics*, vol. 40, no. 7, p. 077301, Jun. 2012, doi: 10.1118/1.4811156.

[6] D. E. A. Pradana, 'Measurement of kV Use in Pediatric Thorax Examination on Image Quality and Radiation Dose.', Jakarta, 2011.

[7] S. Gunawati, M. Irsal, D. Amalia Marina, N. Heru Apriantoro, M. W. Edy, and P. I. Kesehatan Kementerian Kesehatan Jakarta, 'Exposure Index Evaluation of Exposure Factors with the 15 kVp Rule of thumb Method on Radiographic Examination of AP Projection Head', Online, 2021.

[8] M. A. S. Sherer, P. J. Visconti, E. R. Ritenour, and M. Kelli Haynes, *Radiation protection in medical radiography*. Elsevier Health Sciences, 2013.

[9] BAPETEN, 'Decree of the Head of BAPETEN number 9 Year 2011. Conformity Test for Diagnostic and Interventional Radiology X-ray Equipment: Jakarta', 2011.

[10] S. Sugiarti, S. Surip, and M. Fadila, 'Optimasi Faktor Eksposi pada Pemeriksaan Radiografi Thorax menggunakan Computed Radiography: Optimization of Exposure Factors on Thorax

Radiography Examination Using Computed Radiography', *Jurnal Surya Medika (JSM)*, vol. 6, no. 1, pp. 52–56, 2020.

[11] G. Compagnone, L. Pagan, and C. Bergamini, 'Comparison of six phantoms for entrance skin dose evaluation in 11 standard X-ray examinations.', *Journal of applied clinical medical physics / American College of Medical Physics*, vol. 6, no. 1, pp. 101–113, 2004, doi: 10.1120/jacmp.v6i1.2020.

[12] S. Litasova, E. Hidayanto, and D. M. Azam, 'Pengaruh ketebalan dan kombinasi jenis filter terhadap nilai Entrance Skin Exposure (ESE) menggunakan factor eksposi pemeriksaan kepala', *Youngster Physics Journal*, vol. 7, no. 2, pp. 67–75, 2018.

[13] O. D. Pamungkas, 'Optimalisasi Penggunaan Variasi Filter Pada Pesawat Sinar-X Mobile Guna Mencapai Nilai Entrance Skin Exposure (Ese) Sesuai Organ Pemeriksaan', 2020.

[14] K. N. Widyanti, J. A. E. Noor, and P. Juswono, 'Determination and Measurement of X-ray Radiation Absorption Dose on the Surface of Skull Phantom Using Entrance Skin Exposure (ESE) Method. Malang: Brawijaya University', 2013.

[15] M. Azam and E. Setiawati, 'Measurement of Entrance Skin Exposure (ESE) Values with Various Types of Filter Materials on Mobile X-Ray Machines Using Chest Exposure Factors.', *International Journal of Innovative Research in Advanced Engineering (IJIRAE)*, vol. 10, pp. 2349–2163, 2017, doi: 10.26562/IJIRAE.2017.OCAE10084.