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Application of SR-Cu Radioprotector and Tube Current Modulation (TCM) to Reduce Radiation Dose in CT-Scan

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ABSTRACT

CT-Scan using high-dose X-ray radiation has harmful effects on the body or the environment if the utilization is not appropriate. One of the efforts to reduce radiation dose exposure to patients is to use a Silicone Rubber (SR)-Cooper (Cu) mixture as protection during examination. In addition to using composite materials, the mode selection in image capture on CT-Scan modalities can be chosen between Tube Current Modulation (TCM) with constant current. In this study, SR-Cu radioprotector was used for protection in thorax CT-Scan examination with TCM method and a constant current of 200 mAs and variation in Cu composition of 0%, 8%, 10%, and 12% of total radioprotector weight. The results showed that SR-Cu reduced the dose received by the patient by 4.86% while using TCM with SR-Cu reduced the dose by 39.24% compared to TCM without radioprotectors by 37.64%. From the research that has been done, it shows that the use of SR-Cu can increase radiation dose uptake.

Keywords : CT-Scan, Silicone Rubber-Cooper, Shielding, Tube Current Modulation

I. INTRODUCTION

One type of cancer that often occurs in women and causes many deaths is breast cancer. Data from the International Agency for Research on Cancer in GLOBOCAN (Global Cancer Statistic) in 2018, there were 2.1 million new cases of breast cancer found globally or 11.6% with a mortality rate of 626,679 people or 6.6%. The number of incidents to date is still increasing in women with an age range of 40-45

years, if early detection or diagnosis and therapy are carried out quickly and appropriately, the possibility of recovery is higher and is one of the main approaches in dealing with breast cancer patients [1]. Thorax examination using CT scan also detects lung disorders [2]. One modality that is often used to determine the presence or absence of potential cancer is an examination using the CT Scan modality [3]. The use of the CT-Scan modality uses high-energy ionizing radiation, so its use also has the potential to cause stochastic effects on human body tissues, one of which has the potential to cause new cancer effects [4], [5]. Based on the Nuclear Energy Regulatory Agency Regulation Number 4 of 2020 concerning radiation safety in the use of X-ray aircraft in diagnostic and interventional radiology, it is stated that the utilization of radiation must pay attention to the principles of radiation protection for both the general public and its workers. The principles of radiation protection are justification, dose limitation, and implementation of radiation protection and safety optimization [6].

Silicone Rubber (SR) can be used as shielding in examinations [7], [8]. The use of Silicone Rubber (SR)-Lead (Pb) composites can be used as protection in examinations that utilize radiation [9]. Because Pb material is a heavy metal that can be used as a material for radiation resistance [10]. However, the study used thickness variations of 3,6,9 and 12 mm with a Pb composition of 5% of the radioprotector weight. The composition successfully reduced the dose of 5.2, 4.5, 4.3 and 3.3 mGy. However, the study produced artifacts in the image [11].

In another study, it was mentioned that the use of radioprotectors with SR base material with the addition of variations in the composition of Cu or copper powder was successfully carried out and could reduce the dose value received by the body or it could be said that the use of radioprotectors on an electron beam LINAC aircraft with 8 MeV energy could increase the surface dose so that the radiation dose received by the body was reduced. The results obtained are radioprotectors that do not have Cu content have the smallest density, while radioprotectors that have the largest Cu content have the largest density. The radioprotectors used are SR-Cu mixtures with variations in Cu content of 0%, 6%, 8% and 10% by weight with a size of 40 x 30 x 0.5 cm^3[12]. Other metal materials that can be used besides Pb as composites are bismuth (Bi), cooper (Cu) and Barium (Ba) [13], [14].

When using the CT Scan modality, the radiographer can select the image capture mode feature, namely using Tube Current Modulation (TCM) or constant current. This TCM can reduce the dose by 10-60% [15]. The naming of this TCM for each modality has a different name, for example, the GE modality is called SmartMA, Siemens is called Dose4D, while Toshiba is called SureExposure and Philips is called DoseRight [16], [17].

In this study, radioprotectors were used to reduce radiation doses in thorax CT-Scan examinations with the TCM method and a constant current of 200 mAs at a voltage of 120 kVp and variations in Cu composition of 0%, 8%, 10%, and 12%.

II. METHODS AND MATERIAL

In this study, the radioprotector has dimensions of 40 x 30 x 0.5 cm3 using SR-Cu material with Cu variations of 0%, 8%, 10% and 12%. The schematic of the SR-Cu radioprotector manufacturing process is shown in Figure 1. The manufacture of SR-Cu radioprotectors is intended to determine the dose reduction capability in thorax CT-Scan examinations with TCM or constant.

Measurement of thorax organ radiation dose on the Anthrophomorphic phantom using Radcal detector. The Radcal detector is placed on the Anthrophomorphic phantom shown in Figure 2 (a) and for the placement of the radioprotector above the detector so that the radiation received is radiation that

has gone through the SR-Cu material shown in Figure 2 (b).

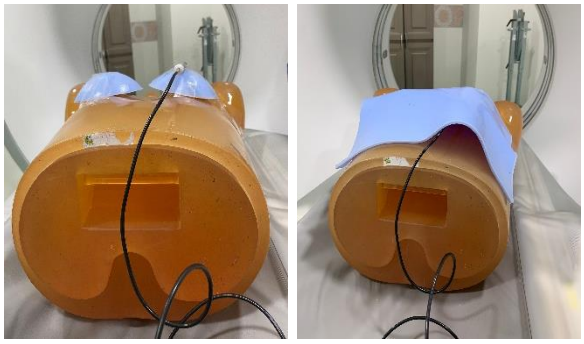

Figure 2. Scanning position of the Antrophomorphic phantom (a) without radioprotector (b) using radioprotector.

The complete parameters in the thorax CT-Scan dose measurement are shown in table1. In this study, CT-Scan thorax dose measurements were repeated 3 times for each parameter tested.

Table 1. Scan Parameters

Scan Parameters	First Scanning	Second Scanning
Tube Voltage (kVp)	120	120
Tube Current (mAs)	TCM	200
Scan Mode	Helical	Helical
FOV (mm)	450	450
Slice Thickness (mm)	5	5

III. RESULTS AND DISCUSSION

Figure 3(a) shows the dose measurements on the surface of the thorax phantom with the SR-Cu radioprotector in the measurement using the TCM method. Figure 3(b) shows the dose measurement on the surface of the thorax phantom with the SR-Cu radioprotector in the constant current method measurement. The results show that when using constant current the dose received is higher than using TCM. In Figure 3, it can be seen that there is a reduction in dose when using SR-Cu radioprotectors with variations of 0%, 8%, 10%, and 12%. The results of dose measurements with constant current and TCM methods using radioprotectors are shown in table 2 and table 3. The dose measurement values in tables 2-4 are the average values from 3 times the dose measurement results. Table 2 shows that the dose reduction of the constant current method on the right side was 2.36%, 5.09%, 7.20%, and 7.80%, respectively. The results of dose reduction on the left side measurements were 1.33%, 6.11%, 10.44%, and 10.72%, respectively. Table 3 shows the results of dose measurement using the TCM method. The right side dose measurement shows a dose reduction of 0.85%, 1.07%, 8.52%, and 11.39%, respectively. The results of dose reduction measurements on the left side were 0.92%, 4.99%, 13.52%, and 14.13%, respectively.

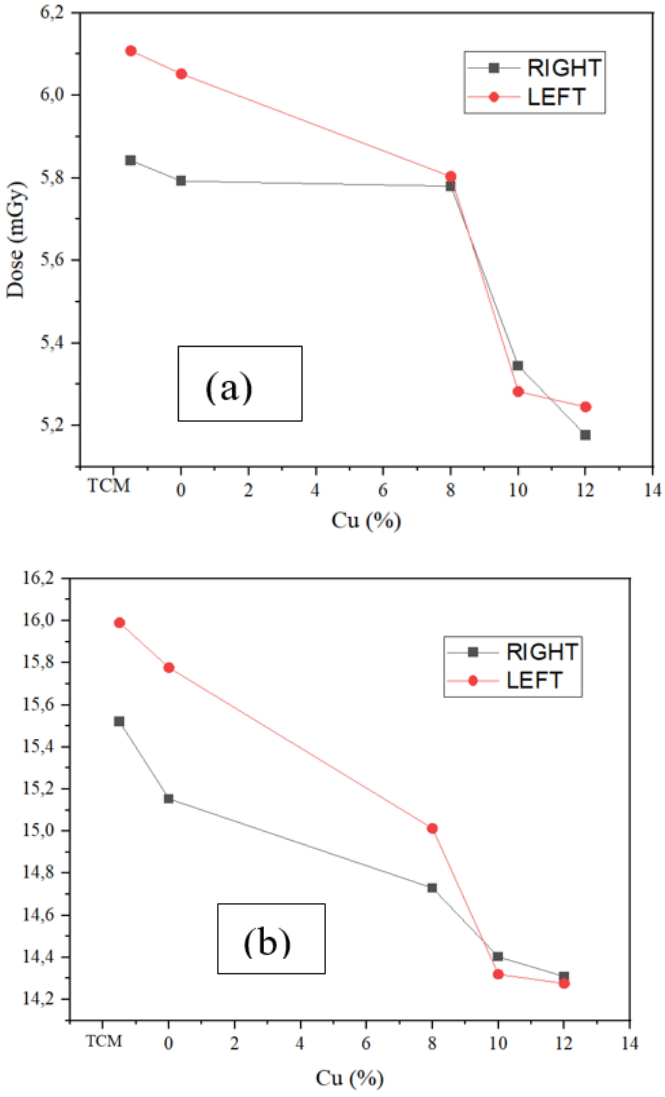

Figure 3. Dose measurement (a) TCM method (b) Constant current method

Between the use of the TCM method and the constant current method, the percentage of dose reduction value is different. In the use of the TCM method, the dose reduction is higher by 14.13% than the use of the constant current method which is 10.72%.

Table 2. Received Dose using the Constant Current Method

No	Variation of Exposure	Dose (mGy)			
		Right	(%)	Left	(%)
1	Body Phantom without radioprotector	15.52	-	15.99	-
2	Body Phantom radioprotector 0%	15.15	2.36%	15.78	1.33%
3	Body Phantom radioprotector 8%	14.73	5.09%	15.01	6.11%
4	Body Phantom radioprotector 10%	14.40	7.20%	14.32	10.44%
5	Body Phantom radioprotector 12%	14.31	7.80%	14.28	10.72%

Table 3. Accepted Dosage using TCM Method

No	Variation of Exposure	Dose (mGy)			
		Right	(%)	Left	(%)
1	Body Phantom without radioprotector	5.84	-	6.11	-
2	Body Phantom radioprotector 0%	5.79	0.85%	6.05	0.92%
3	Body Phantom radioprotector 8%	5.78	1.07%	5.80	4.99%
4	Body Phantom radioprotector 10%	5.34	8.52%	5.28	13.52%
5	Body Phantom radioprotector 12%	5.18	11.39%	5.25	14.13%

The results in tables 2 and 3 show that the use of SR-Cu-based radioprotectors is able to reduce the dose, both using the constant current method and using the TCM method in measuring the dose on the surface of the thorax organs. Tables 4 and 5 show that the TCM method without the use of radioprotectors can reduce the dose by 37.64% on the right side, while on the left side the dose is reduced to 38.20%. When compared between the TCM method and constant current for the use of SR-Cu radioprotectors, the dose received was reduced by 39.24% on the right side, and 38.65% on the left sides.

Table 4. Dose Measurement Comparison Results using TCM Method and Constant Current (Right)

No	Variation of Exposure	Dose (mGy)		
		Constant Current	TCM	(%)
1	Body Phantom without radioprotector	15.52	5.84	37.64%
2	Body Phantom radioprotector 0%	15.15	5.79	38.23%
3	Body Phantom radioprotector 8%	14.73	5.78	39.24%
4	Body Phantom radioprotector 10%	14.40	5.34	37.11%
5	Body Phantom radioprotector 12%	14.31	5.18	36.18%

Table 5. Dose Measurement Comparison Results using

TCM Method and Constant Current (Left)

No	Variation of Exposure	Dose (mGy)		
		Constant Current	TCM	(%)
1	Body Phantom without radioprotector	15.99	6.11	38.20%
2	Body Phantom radioprotector 0%	15.78	6.05	38.36%
3	Body Phantom radioprotector 8%	15.01	5.80	38.65%
4	Body Phantom radioprotector 10%	14.32	5.28	36.89%
5	Body Phantom radioprotector 12%	14.28	5.25	36.74%

From tables 4 and 5, it can be seen that the use of the TCM method can reduce the dose by 39.24% when compared to using the constant current method, which is the largest dose reduction of 10.72% in the examination using CT-Scan thorax. This is because in using the TCM method, the modality is set so that the dose received by the patient can be less by maintaining the Noise Index (NI) value on the image so that it can still be read.

IV. CONCLUSION

The results showed that the use of SR-Cu (12%) radioprotectors was able to reduce the smaller dose with a difference of 10.72% in the constant current method. The results of using the SR-Cu (12%) radioprotector can reduce smaller doses with a difference of 14.13% in the TCM method. The use of the TCM method can curtail a larger dose of 39.24% compared to the constant current method.

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