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Evaluation of Exposure Index (S-Value) in Radiological Examination of Posterior Anterior Thorax as the Effort of Improving Patient Radiation Protection

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Abstract— *Digital radiography is an easy method of radiological examination, so many radiology technicians often use high exposure factors because they are considered to speed up when processing images, this can increase the risk of excessive radiation doses in patients, currently the exposure index (IE) is feedback to radiology technicians for optimal images and low doses for patients. Objective: evaluating Fujifilm (S-Value) exposure index and entrance surface dose (ESD) thorax posterior-anterior as an effort to increase patient radiation protection using the ALARA principle, Method: Data taken from samples with parameters 64 kVp 16 mAs to 94 kVp 2 mAs, ESD is measured using the thermoluminescent dosimeter (TLD) chip and exposure index (S-Value) from Fujifilm's direct radiography device. Result: The relationship between S-Value and ESD has an exponential trend graph. The rise of S-Value will be followed by the ESD sequence. With the BAPETEN reference value of surface radiation dose 0.40 mGy, the minimum S-value must be achieved so that the patient's ESD does not exceed S-532 at ESD 0.39. Conclusion: The results of this study indicate that Fujifilm's S-Value allows it to be used as an evaluation of the ESD values received by patients as an effort to increase patient radiation protection.*

Keywords— *Fujifilm exposure index, ESD, chest radiography, radiation protection.*

I. INTRODUCTION

X-rays are an inseparable part of a health service, and at present, almost all health facilities can be sure to have x-ray equipment to get radiographic images of anatomical organs [1]. One of the tests that are often done is radiography of the thorax, radiographic of the thorax posterior anterior is an examination which is very important to assess the heart and abnormalities the respiratory system part below [2], in January 2016 there are less as there 156.723 tuberculosis, 503.738 patients with pneumonia [3],[4].

On radiological examination of thorax radiation dose patient should pay attention to the concept of As Low As Reasonably Achievable (ALARA) the radiation doses remained low, with good quality images to provide accurate information [5].

In line with the development of conventional digital image processing technology began to be replaced by digital radiographic systems that have a wider dynamic range than conventional systems [2]. Digital radiography has disadvantages, namely the exposure factor that is too low which will cause increased noise or sound and decrease the radiograph image detail, while the use of high exposure factors will reduce noise and improve detailed image [6]. This triggers most radiographic technicians to use high exposure factors to get a good image and improve image processing, but this can lead to the potential for increased radiation exposure to patients [5].

To avoid increased radiation exposure and maintain the image quality, radiographic equipment manufacturers develop exposure index (IE). The exposure index is used to show the relative speed and sensitivity of x-ray digital receptors and provide feedback to radiology technicians about appropriate radiographic techniques, to obtain optimal images and low doses suitable for patients [7].

Patient radiation dose evaluation is a very important thing to do because the increase in dosage on medical exposure is very high [8]. The most common radiation dose method is using thermoluminescent dosimeter (TLD) to obtain an entrance surface dose (ESD) [9]. However, based on a preliminary study conducted in August 2017 on 15 health facilities in East Java Indonesia, there was no facilities Thermoluminescent dosimeter (TLD) that were sufficient for the entrance surface dose (ESD) evaluation or radiographic equipment that estimated radiation doses in patients. who were studied? that is the radiographic exposure index, therefore in this study. In this study aims to evaluate the index of digital radiographic exposure on thorax posterior anterior radiography as an effort to optimize radiation protection in patients.

II. RESEARCH METHODS

Data were taken from patients on posterior anterior thorax radiograph examination using Shimadzu X-ray equipment and Fujifilm Drypic digital radiographic equipment. Before the examination was carried out the sample measured body weight, height to get a body mass index (BMI) and chest thickness. The sample is divided into four groups and uses the inspection parameters in Table 1.

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TABLE 1. Parameters of Thorax postero anterior radiographic examination

Group	Tube tension (kV)	Time of exposure (s)	Secon tube current (mAs)
A	64	0,08	16
B	74	0,04	8
C	84	0,02	4
D	94	0,01	2

The examination used was a fixed tube current of 200 mA, focus film distance (FFD) 150 cm, width of collimator 35 x 35 cm. The reading of the Fujifilm exposure index (S-Value) was taken from the results of X-ray radiation exposure to patients directly read by computer systems on X-ray equipment, to obtain the surface dose values received by patients using the TLD placed at the midpoint of at the center of X-rays shown in figure 1.

Fig. 1. Used chip TLD

The dose is obtained by multiplying the amount of the charge with the conversion number, while the ESD value is obtained by the equation:

$$ESD = R\ .\ FK \quad (1)$$

a minimum of 2 (two) TLD chips are needed in 1 (point) used for measurement and the average ESD value is taken.

$$ESD_{rerata} = \frac{TLD_1 + TLD_2}{2} \quad (2)$$

The data obtained included radiographic exposure index values obtained from calculations on computer radiography and ESD calculations obtained using equations 1 and 2 obtained from TLD readings, then carried out descriptive analysis with a related theoretical approach.

III. RESULTS AND DISCUTION

Entrance surface dose (ESD) of surface radiation thorax posteror anterior examination.

TABLE 2. ESD values for examination of Thorax posterior anterior

Group	kV	mAs	Minimal	Maximal	Mean	Standard deviasi
A	64	16	0,45	0,65	0,53	0,05
B	74	8	0,31	0,62	0,47	0,07
C	84	4	0,35	0,59	0,42	0,08
D	94	2	0,20	0,46	0,32	0,07

Relationship between entrance surface dose (ESD) and exposure index (S-Value). The exposure index (S-Value) obtained from this study has a variance value can be seen in Table 3.

TABLE 3. Exposure index value (S-Value) examination of thorax posterior anterior

Group	kV	mAs	Minimal	Maximal	Mean	Standard deviasi
A	64	16	263	447	348	55,4
B	74	8	251	499	360	80,2
C	84	4	287	573	419	76,6
D	94	2	448	786	661	98,8

From the results of measurements and calculations obtained in this study, the relationship between entrance surface dose (ESD) and Fujifilm exposure index (S-Value) on the posterior-anterior thorax radiograph can be seen in figure 2.

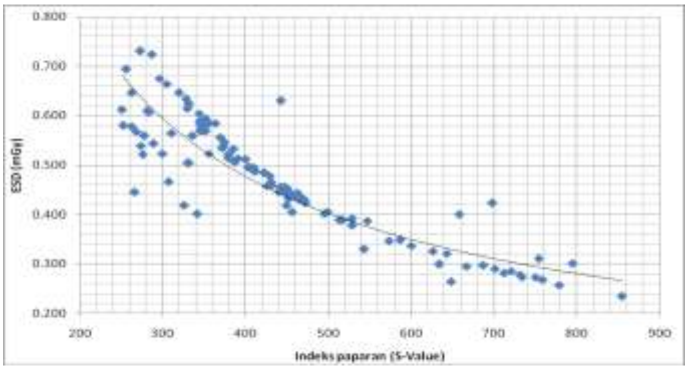

Fig. 2. Graph of the relationship between entrance surface dose (ESD) and S-Value Index.

In this study, the index of radiographic exposure to FujiFilm (S-value) having a characteristic reduction in entrance surface dose (ESD) will increase the exposure index (S-value) seen in figure 2, and vice versa, which means the relationship between surface dose and exposure index (S-value) Thorax posterior-anterior radiological examination using Fujifilm digital radiography is inversely proportional where low exposure will produce a high S value, and high exposure will result in a low S value[10].

Exposure index value (S-Value) produced by X-ray radiation after passing through the material, after arriving at the receptor image will be converted to grayscale and displayed in the pixel matrix of the image, Fujifilm's radiographic exposure index uses sensitivity values that represent numerical values received by image receptors[11].

The radiation intensity or radiation dose received on the surface of the object and the intensity of radiation that reaches the image receptor has this difference due to the weakening of radiation by the material, the change in radiation intensity (dl) affected by changes in thickness (dx) can be use in equation 3.

$$dI(x) = -I(X).n.\sigma.dx \quad (3)$$

From figure 2 the relationship between entrance surface dose (ESD) and exposure index (S-Value) has an exponential function trend, this is because the intensity of x-rays reaching the image receptor is affected by the chest thickness of the patient's sample, so equation 4 applies

$$I_x = I_o.e^{-\mu x} \quad (4)$$

In Fujifilm equipment S-Value has a value that is inversely proportional to the intensity of x-rays that arrive at the image

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receptor, this is because the sensitivity value is the inverse value of the speed of the image receptor and the sensitivity value can be considered equivalent to the speed of the image receptor, If the exposure value is low, the image receptor speed will increase and will increase noise, at high exposure to image receptors will decrease [10].

one of the radiation protection requirements that must be fulfilled is the principle of optimization of protection, the purpose of this optimization principle is an effort to make the received dose as low as possible (As Low As Reasonably Achievable - ALARA) and optimization is interpreted as an attempt to make the dose received by the patient as low as possible while maintaining the image quality obtained as optimal as possible [12].

Patient radiation exposure does not have a dose limit value but the dose received by the patient must be justified and optimized so that it can prevent receiving unnecessary radiation exposure [9].

Based on the graph of the relationship between surface radiation dose and exposure index (S-Value) and paying attention to exposure guidelines for radiation doses issued by BAPETEN on posteroanterior thorax examination can be seen in figure 3. Radiographic technicians can make efforts to increase patient radiation protection in one way by paying attention to the exposure index (S-Value).

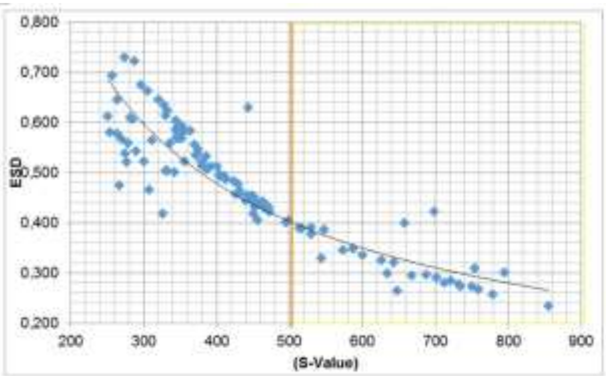

Fig. 3. Graph of the relationship between entrance surface dose (ESD), exposure Index. (S-Value) and guidelines radiation dose BAPETEN

From figure 3 the red line is the guide limit of posterior-anterior thorax radiation 0,40 mGy [12], so that it can be seen in Fujifilm's direct digital radiography for the Fujifilm exposure index posterior anterior thorax (S-Value) examination above 532 seen in the yellow area which has a maximum value ESD of 0,39 mGy, so that the patient's surface radiation dose value does not exceed the Diagnostic Reference Level (DRLs) issued by BAPETEN

IV. Conclusion

Entrance surface dose (ESD) with the Fujifilm radiographic exposure index (S-Value) has an exponential tendon relationship where a decrease in entrance surface dose (ESD) has an impact on the higher value of the exposure index (S-Value). The Fujifilm (S-Value) radiographic exposure index reconditioned from the results of this study for posterior-anterior thorax examination, which must be attempted above 523 so that the surface radiation dose received by the patient does not exceed the DRLs value issued by BAPETEN of 0,40 mGy.

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