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Analysis of Image Quality and Radiation Dose in Lumbar and Pelvic Examination Using the Copy Image Feature : A Phantom Study

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ABSTRACT

Copy image is a software feature that is capable of duplicating images. So it can reduce errors in overexposure in patients. The purpose is to analyze feature usage images on radiation dose and image quality in lumbar and pelvic radiographic examinations. This research method uses quantitative with an experimental approach and research review. This research was carried out at Pertamina central Hospital Jakarta in February – March 2023 with the tools and materials used: X-ray multipurpose, computer radiography, and phantom anthropomorphic. For radiation dose, use the calculated value does area product (DAP), while for radiographic image quality use the range indicator exposure index (EI). The analysis carried out was comparing the use of copy images on radiation dose and image quality in lumbar and pelvic examinations. Results of using features copy image show a higher radiation value than examining the lumbar and pelvis separately one by one, while for image quality the value exposure index shows optimal indicators. Radiographers are expected to be wiser in implementing radiation protection when using procedures to copy images by minimizing the area of the collimation field.

Keywords: Dose Area Product (DAP), Exposure Index, Radiation Protection

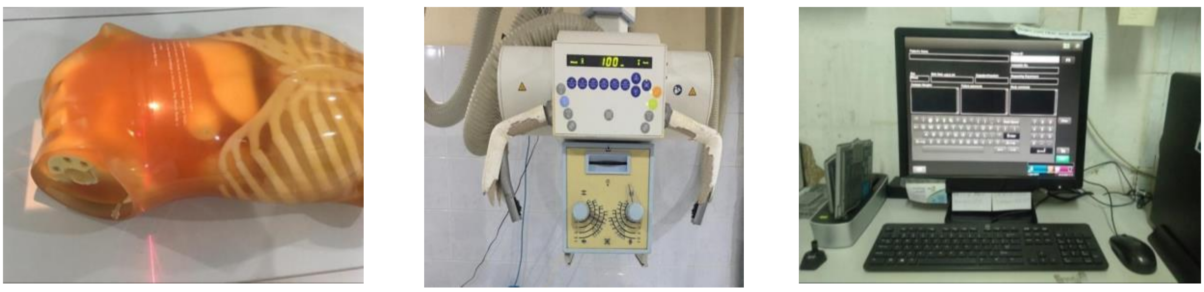
I. INTRODUCTION

Wilhelm Conrad Roentgen accidentally discovered a type of radiation known as X-rays. X-rays are called ionizing radiation because of their ability to ionize objects when passing through them by being emitted through a tube and then directed at the object and the X-ray beam penetrates and is captured by film, thus forming a picture or image of the object being illuminated. X-ray radiation plays an important role in life, especially in its use in the health sector, because related to the field of service known as radiological examination, which aims to support medical diagnosis. The examination includes conventional radiography, MRI, and CT scan [1], [2]. The radiographic examination does not escape the effects that will be caused to the patient due to the interaction of X-rays with body cells. The effects caused by radiation are deterministic effects and stochastic effects. Deterministic effects are effects that have a threshold dose and symptoms will appear immediately after receiving high doses of radiation exposure. Meanwhile, stochastic effects are effects that occur without a threshold dose and there is a grace period before symptoms appear [3].

The radiographic examination aims to obtain clinical information from the patient. This information is obtained through imaging results evaluated by a doctor so that it can be used as a diagnostic tool and to determine further action for the patient. In the field of radiodiagnostics, determining the accuracy of a disease diagnosis is greatly influenced by the quality of radiography. However, by the ALARA principle (As Low As Reasonably Achievable), the dose received must be as low as possible for each use of radiation sources, both for patients, radiation workers, and the public [4].

Image quality is a requirement to show the accuracy or representation of the patient's anatomical part in a radiograph. An image that can clearly show structures and soft tissue is said to be of good quality. Meanwhile, an image is said to have poor quality if it contains images that are difficult to differentiate from the human eye. Image quality (image quality) optimally with quantitative images helps accuracy in diagnosis, to avoid errors in diagnosis. Radiology specialists need good-quality radiographs to be able to make an accurate diagnosis. The quality of the radiograph is affected by voltage tube and filtration, while the quantity of radiographs is influenced by tube voltage, current strength and time, Focus Film Distance (FFD), object thickness, and filtration. According to Bontrager, the factors used to evaluate the quality of digital images are brightness, contrast, resolution, distortion, noise, and exposure Index (EI) [5].

Along with advances in science and technology, film screens in conventional radiography are starting to be abandoned. The radiographic technique modality used for medical purposes in hospital radiology departments is increasingly shifting to filmless digital radiography technology, namely using a digital detector system or Digital Radiography. A radiograph (imaging) is produced directly when the examination is carried out and then transferred to the computer system without using intermediary tapes. Digital radiography technology not only produces digital image acquisition modalities but also has features for radiological image processing. Feature copy image in image processing is a feature developed in software



(a) (b) (c)

FIGURE 1. (a). phantom anthropomorphic, (b). X-ray Multipurpose. (c). Computer radiography

that is capable of duplicating previously taken radiological images. The aim of using this feature is to duplicate the existing image without having to re-expose it, thereby reducing the exposure received by adjacent organs in the lumbar and pelvis [6], [7].

In addition, the use of collimation in radiographic examinations requires special attention in radiographic examination procedures when using the maximum collimation field size, because it can increase the radiation dose received by the patient [8]. In some cases, the hospital features copy images It is used to optimize radiographic examinations because it can combine two lumbar and pelvic radiographic procedures into one examination procedure so that patient exposure is not repeated. Therefore, it is necessary to analyze the usage of copy images on radiation dose and image quality in lumbar and pelvic radiographic examinations.

II. METHODS AND MATERIAL

This research uses quantitative methods with an experimental and experimental approach review study. This research was carried out at Pertamina Hospital Jakarta in February – March 2023 with the tools and materials used: X-ray equipment, computer radiography, phantom anthropomorphic, shown in Figure 1. For radiation dose, use the calculated value does area product (DAP), while for radiographic image quality use the range indicator exposure index (EI). Calculation of radiation dose using the method output radiation using power function $y=0.0065x^{1.9885}$ the results of entrance surface dose (ESD) equation is as follows:

$$ESD(\mu Gy) = 0{,}0065xkV^{1{,}9885}\,xmAsx\left(\frac{FFD}{FD}\right)^2$$

With kVp is the tube voltage used by the X-ray machine, tube current-time mAs, FFD is the distance between the focus and the film, and FD is the distance between the focus and the radiation detector during the suitability test. Next, to determine the effect of the collimation field area, we use calculations of Dose Area Product (DAP) with the following equation:

$$DAP = \frac{ESD\ .A}{BSF}$$

Where A is the value of the area of the collimation field, BSF or Backscatter factor the conversion value is based on TRS 457. Next, for image quality, use the EI parameter as an indicator of underexposure or lack of radiation exposure which results in a decrease in image quality with increased noise, the optimal indicator is an acceptable image with balanced radiation dose and image quality. Indicator overexposure shows an increase in radiation dose with greatly improved quality. However, overexposure is not recommended [9], [10], [11], [12], [13]. The analysis carried out compared usage copy images on radiation dose and image quality in lumbar and pelvic examinations.

TABEL 1. Radiographic Examination Procedure

Parameters	Radiographic Examination Procedure		
	Copy image	Lumbar AP	Pelvis AP
Position	supine	supine	supine
Central ray	Vertical	Vertical	Vertical
Central point	Lumbar 5	Lumbar 3	SIAS
Focus film distance	100	100	100
Collimation	35 cm x 43 cm	18 cm x 43 cm	35 cm x 25 cm
Exposure factors	71 kV, 22 mAs	71 kV, 22 mAs	71 kV, 22 mAs

III.RESULTS AND DISCUSSION

One of the advantages of using digital radiography is the use of featurescopy image which is the ability of digital images to store and duplicate images without decreasing image quality. Apart from that, in the last few decades, there have been several studies that have been carried out with results showing that digital image results can be better assessed directly on a monitor compared to reading using radiographic film [14].

Radiographic examination procedure with features copy image, lumbar and pelvic are shown in Table 1. From the research results of measuring the DAP radiation dose using equation 2, it is shown in Table 2 with the highest value shown in the use of the copy image compared with lumbar and pelvic radiographs. This is caused, by the size of the feature field copy image which is larger than the lumbar and pelvic examinations.

Featured image results copy image, lumbar and pelvis are shown in Figure 2. Next, image quality analysis uses the indicator exposure index with the results shown in Table 2. The exposure index is the response of the radiation detector or CR cassette to relevant imaging results, meaning that EI is not related to the radiation dose received by the patient. However, EI corresponds to a level of radiation exposure that is proportional to the value signal-to-noise ratio (SNR). The results of this research are shown in Table 2. All indicator ranges are included in the optimal indicator section. According to Seraam, the optimization range for using EI CR Fuji film is 150-200. Additionally, for EI on the range underexposure 400-2000. As for range overexposure 100-20 [11], [15]. In some cases, the increase in dose can be caused by changes in the size of the field which becomes larger when using digital radiography, so that there is also an increase exposure index toward overexposure [16]. Changes in collimation do not affect the quality of radiographic images, the results of research by Agustina et al., show that there is no difference in image quality when changes in collimation field area become larger. Apart from that, a radiographer needs to be careful when selecting a larger collimation field area [17].

The use of ionizing radiation in the field of radiology must be based on optimization, namely by considering the minimum possible dose with acceptable image quality. One factor that can increase the radiation dose is the size of the collimation field.

(a) (b) (c)

FIGURE 2. Radiographics: (a). Copy image, (b). Lumbar AP, (c) Pelvic AP

TABLE 2. Results image quality and radiation dose

Radiographics	Field size	DAP (μGy x cm²)	Exposure index
Copy image	35 cm x 43 cm	10.2	145
Lumbar AP	18 cm x 43 cm	5.3	136
Pelvis AP	35 cm x 25 cm	5.9	196

Therefore, it is necessary to limit the field area in accordance with radiographic examination procedures so that the radiation dose and image quality can be controlled during the radiographic examination [18]. Radiographers need to be wiser in using the wide collimation field when carrying out radiographic examination procedures. The research report shows that the increase in EI can be caused by an increase in the size of the field. Although the increase in EI is relatively smaller and still within the range acceptable based on the criteria exposure index. However, it should be noted that increasing the size of the collimation field can provide excessive radiation dose to organs and will have a negative impact on the cells and tissues being irradiated19. Setting the size of the radiation field is one of the problems in radiographic examination procedures, this is related to image quality and increasing radiation dose. Scattered radiation caused by the use of a wide field of collimated irradiation can also affect the contrast value and quality of the radiographic image [20].

IV. CONCLUSION

The copy image feature shows a higher radiation value compared to examining the lumbar and pelvis separately one by one, however, to minimize radiation exposure to the organs copy image can be considered as an optimization procedure. Meanwhile, for image quality, the exposure index value shows the optimal indicator. Radiographers are expected to be wiser in implementing radiation protection in using image copying procedures by minimizing the collimation field size area.

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