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# Literature study on the effect of exposition factors on image quality in the aspect of gray degree

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## ABSTRACT

This literature study aims to examine the influence of exposure factors on the quality of radiographic images in the field of radiodiagnostics. Three scientific journals were used as research materials, focusing on adjusting tube voltage (kV) and exposure time (mAs) to optimize image quality. Experiments were conducted using Computed Radiography (CR) and Digital Radiography (DR) on different phantoms, such as water in a plastic bag as phantom, ossa manus phantom (hand), and abdominal phantoms. The results of the study indicate that the optimal combination of tube voltage and exposure time varies depending on the density and thickness of the tissues being examined. In conclusion, the proper adjustment of exposure factors is key to obtaining high-quality radiographic images for diagnosing diseases or lesions.

**Keywords:** Exposure factors; images; phantom; radiography

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## INTRODUCTION

Ideal healthcare for the entire community requires a supporting field. One such field is the examination field, which assists in diagnosing lesions. One field capable of diagnosing disease is radiodiagnostics. This field diagnoses lesions or diseases using X-ray radiation. This is possible thanks to technological advances in health examinations. Generally, every hospital already has these devices; the most common devices found in hospitals are Computed Radiography (CR) and Digital Radiography (DR) [1].

CR and DR require regular Quality Control (QC) to maintain and ensure the quality of the equipment and maximize the quality of the images produced. If the image quality is poor, the information provided by the image will not be optimal. If the information provided is not optimal, it will be difficult to diagnose a disease or lesion. The examination is expected to produce high-quality radiographic images with minimal radiation exposure [2]. This fulfills one of the principles of radiation protection, namely justification. Justification states that the benefits obtained from the use of radiation far outweigh the risks posed by the radiation [3].

Several factors influence the quality of radiographic images, including density, contrast, and sharpness. One of these factors is the exposure factor. The exposure factor is a factor that influences the quality and quantity of X-ray radiation emitted by the X-ray machine required to produce a radiographic image. The exposure factor consists of tube voltage (kV) and current-time (mAs). Proper adjustment of these exposure factors can produce optimal image contrast to provide maximum information [4].

## RESEARCH METHODS

This research was conducted using a literature study method. The literature study method is one way of research by collecting library data, reading, recording, and processing the data into a study [5]. For this research, 3 libraries were used in the form of scientific journals whose contents were about the effect of exposure factors on the quality of radiographic images, by varying the tube voltage (kV) and time-current (mAs) to obtain

the optimum exposure factor to obtain good image quality. The scientific journals used in this literature study are entitled "The Effect of Exposure Factors on Radiographic Image Quality" (2017), "The Effect of Tube Voltage (kV) on Radiographic Image Quality of Digital Radiography (DR) X-ray Machines on the Abdomen Phantom" (2017), and "The Effect of Exposure Factors on Radiographic Image Quality on Thorax Phantom with PA Projection" (2022).

## RESULTS AND DISCUSSION

In the journal "The Effect of Exposure Factors on Radiographic Image Quality," a study was conducted on X-ray irradiation using CR on a phantom consisting of water in a plastic bag placed on a CR cassette, and its distance from the tube was set at 1 m. Several experiments were conducted with variations in tube voltage (kV), namely, 60 kV; 65 kV; 70 kV; 75 kV; and 80 kV, and current-time (mAs) of 20 mAs; 25 mAs; and 30 mAs. The following are the results of the experiments conducted.

Table 1 shows that at a 20 mAs current-time voltage, the water phantom image has fairly good quality at the 60 kV and 65 kV tube voltages, due to the clear sharpness and contrast. For the 70 kV tube voltage, the contrast is predominantly gray, making it difficult to distinguish the individual parts, indicating poor image quality. Meanwhile, for the 75 kV and 80 kV tube voltages, the dominant color is black or darker. This indicates that the water phantom image quality at the 75 kV and 80 kV tube voltages cannot be considered good, as it is difficult to see the object.

Table 2 shows the image results from a 25 mAs current-time voltage with various tube voltages. Only the 60 kV tube voltage image shows good contrast and sharpness, allowing objects to be clearly visible. The 65 kV, 70 kV, 75 kV, and 80 kV tube voltage images show poor quality, as the grayscale is predominantly black, making objects difficult to see, or even completely invisible.

**Table 1.** Radiographic image results with a 20 mAs current-time voltage [1].

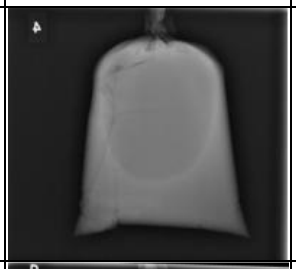
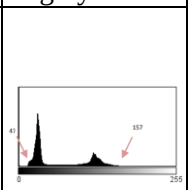
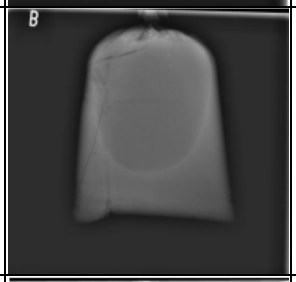
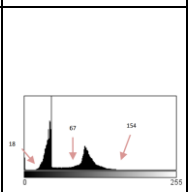
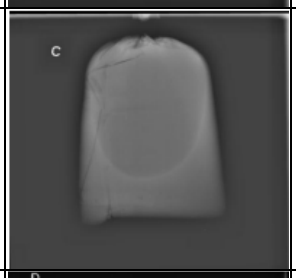
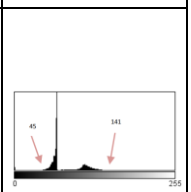
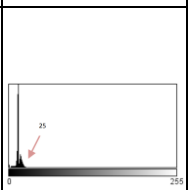
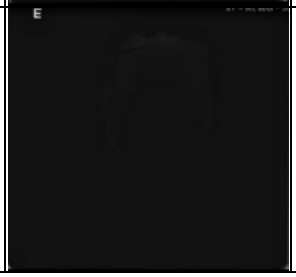
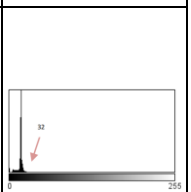
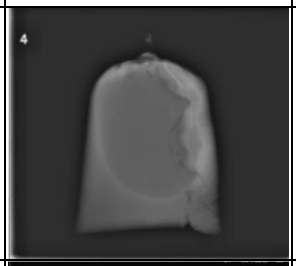
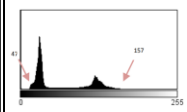
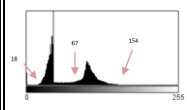
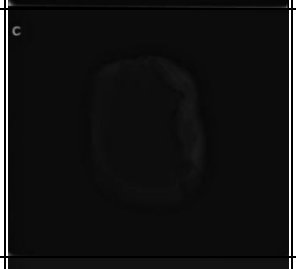
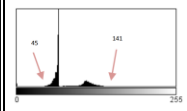
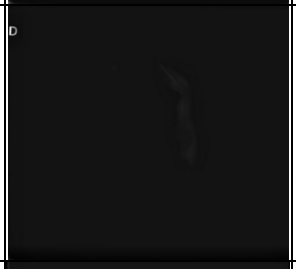
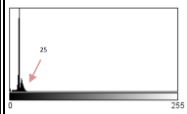
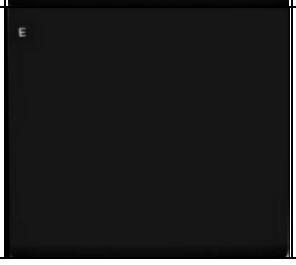
| Tube voltage | Radiography image results | Image grayscale |
|---|---|---|
| 60 kV |  |  |
| 65 kV |  |  |
| 70 kV |  |  |
| 75 kV |  |  |
| 80 kV |  |  |

Table 3 shows the image results at a 30 mAs current-time voltage. This table shows that at 60 mAs and 65 mAs tube voltages, the object is still visible but with very low contrast and sharpness. At 60 mAs, the image is too dark or predominantly black, and at 65 mAs, the image is too light or predominantly gray. For 70 kV,

75 kV, and 80 kV tube voltages, the image results show no image (the phantom is not visible). This indicates that the water phantom with a 30 mAs current-time voltage does not produce good image quality for the tube voltage variations specified for this experiment.

**Table 2.** Radiographic image results with a 25 mAs current-time voltage [1].

| Tube voltage | Radiography image results | Image grayscale |
|---|---|---|
| 60 kV |  |  |
| 65 kV |  |  |
| 70 kV |  |  |
| 75 kV |  |  |
| 80 kV |  |  |

The journal, "The Effect of Tube Voltage (kV) on the Quality of Digital Radiography (DR) X-ray Images on an Abdominal Phantom," the journal presents the results of a study using DR to obtain images from an abdominal phantom. This experiment was conducted 10 times with varying tube voltages: 40 kV, 45 kV, 50 kV, 55 kV, 60 kV, 65 kV, 70 kV, 75 kV, 80 kV, and 85 kV. The following table shows the results of the experiment.

**Table 3.** Radiographic image results with a 30 mAs current-time voltage [1].

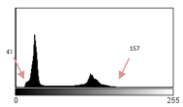
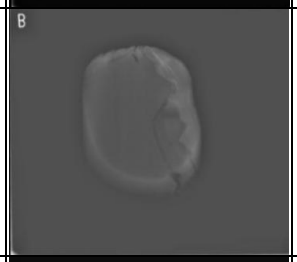
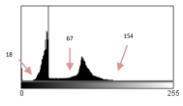
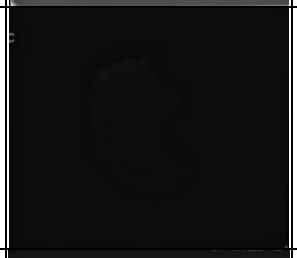
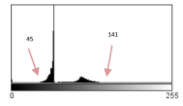
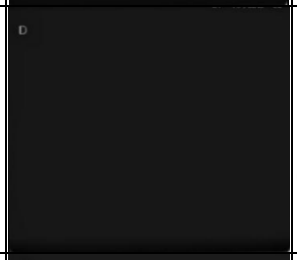
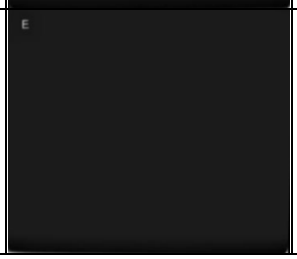
| Tube voltage | Radiography image results | Image grayscale |
|---|---|---|
| 60 kV |  |  |
| 65 kV |  |  |
| 70 kV |  |  |
| 75 kV |  |  |
| 80 kV |  |  |

Table 4 shows the results of DR images with an unknown current-time value but varying tube voltages.

**Table 4.** Radiographic image results with a 30 mAs current-time value [2].

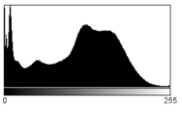
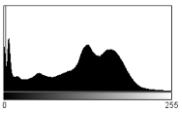
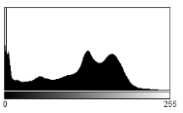
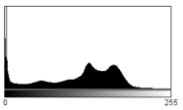
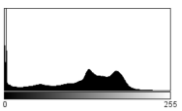
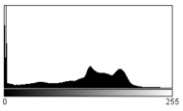
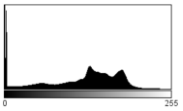
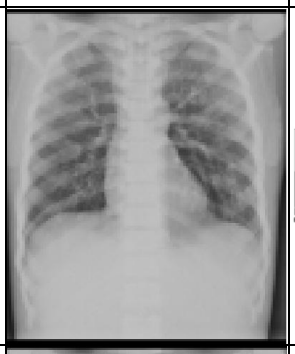
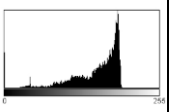
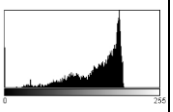
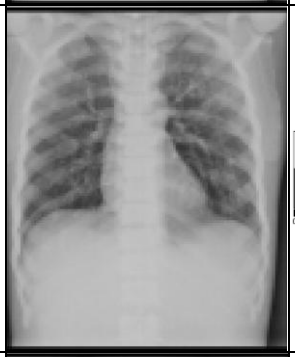
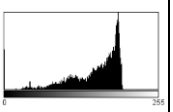
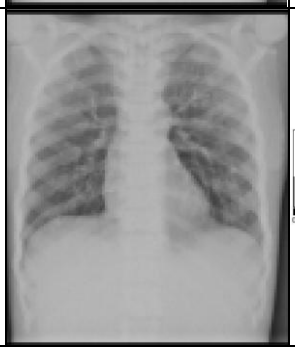
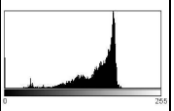
| Tube voltage | Radiography image results | Image grayscale |
|---|---|---|
| 40 kV |  |  |
| 45 kV |  |  |
| 50 kV |  |  |
| 55 kV |  |  |
| 60 kV |  |  |
| 65 kV |  |  |
| 70 kV |  |  |
| 75 kV |  |  |
| 80 kV |  |  |
| 85 kV |  |  |

**Table 5.** Radiographic image results with 30 mAs current-time [4].

| kV | mAs | Radiography image results | Image grayscale |
|---|---|---|---|
| 55 | 10 |  |  |
| 55 | 12 |  |  |
| 60 | 10 |  |  |
| 60 | 12 |  |  |

Tube voltages of 40 kV, 45 kV, 50 kV, and 55 kV produced images with good sharpness and clarity, but noise interfered with the images, making them less than satisfactory. A tube voltage of 60 kV produced good image quality because the image had good sharpness and contrast, as evidenced by the nearly even distribution of grayscale colors, allowing for

clear image visibility and maximum information. At tube voltages of 65 kV, 70 kV, 75 kV, 80 kV, and 85 kV, the dominant color tends to be bright, which reduces contrast. This can be seen in the grayscale histogram, which tends to be high in the lighter areas. Consequently, the image quality can be considered poor or not providing optimal information.

A recent paper entitled "The Effect of Exposure Factors on Radiographic Image Quality on a Thorax Phantom with PA Projection" presents the results of a study using CR to obtain images from a thorax phantom. This experiment was conducted in The experiment was performed four times with varying combinations of tube voltage and current-time: 55 kV with 10 mAs, 55 kV with 12 mAs, 60 kV with 10 mAs, and 60 kV with 12 mAs. The following table shows the results of the experiments.

Table 5 shows the CR image results with several different exposure factor combinations: 55 kV with 10 mAs, 55 kV with 12 mAs, 60 kV with 10 mAs, and 60 kV with 12 mAs. It was found that there were no significant differences between the resulting images, as can be seen visually and from the grayscale. It can be concluded that all of the images are of good quality and provide sufficient information.

## CONCLUSION

Based on the data obtained from this literature study, in the first journal entitled "The Effect of Exposure Factors on Radiographic Image Quality" it is known that the optimum exposure factor to obtain good image quality is at a tube voltage of 60 kV and a current-time of 25 mAs. For the second journal entitled "The Effect of Tube Voltage (kV) on the Quality of Radiographic Images of Digital Radiography (DR) X-ray Machines on the Abdomen Phantom" the optimum exposure factor for the abdominal phantom to obtain good quality images is at a tube voltage of 60 kV and an unknown current-time. In the last journal entitled "The Effect of Exposure Factors on Radiographic Image Quality on Thorax Phantom with PA Projection" the optimum exposure factor for the thorax phantom to obtain good quality images is at different combinations, namely, 55 kV with 10 mAs, 55 kV with 12 mAs, 60 kV with 10 mAs, 60 kV with 12 mAs. The images produced by different exposure factors do not have much difference in image quality, this can be seen visually and in the degree of gray. It can be concluded from the three journals that each part of the human body requires a different combination of exposure factors depending on the thickness and density, because if the body part has a high density or thickness, the X-rays will be absorbed more than the body part or object with low or thin density [6].

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