International Journal of Allied Medical Sciences and Clinical Research (IJAMSCR)

ISSN:2347-6567

IJAMSCR |Volume 8 | Issue 2 | Apr - Jun - 2020
www.ijamscr.com

Research article *Medical research*

Limitation of radiation dose exposure with the selection of radiography grid ratio

Fadli Felayani, Siti Rosidah, Daniel Manurung

Radiology Diploma Program, Widya Husada University, Semarang, Indonesia

***Corresponding Author**: **Fadli Felayani**

Email id: fadli.tro.zone@gmail.com

ABSTRACT

Background

The higher value of the grid ratio, the greater radiation absorbed by the grid strip, thus affecting the use of exposure factors on radiographic examinations. Increased exposure factors may cause an increase in radiation doses in patients.

Objective

This study aims to determine the grid ratio that produces optimal radiographic contrast (gamma) with a low dose.

Methods

The sample used 3 grid ratios of 1:5, 1:6, 1:8, and 1:10. The grid was exposed by placing on it a container filled with water with a water height of 10 cm. Step wedge was placed in water as high as 5 cm from the bottom of the container. Radiographic contrast was measured from gamma on a straight line curve. Samples were exposed with 70 kV, 75 kV, 80 kV, 85 kV, 90 kV and the radiation doses were measured. Statistical tests was conducted include grid ratio correlation test with gamma value, gamma value difference test, and EI index deviation test with tube tension.

Results

There was a significant difference between gamma value with the grid ratio of 1:5 ($p < 0.05$) with 1:6, 1:8 and 1:10. There was no significant difference ($p > 0.05$) between gamma value with the grid ratio of 1:6 with 1:8 and 1:10. Increasing the grid ratio from 1:6 to 1:8 caused an increase in radiation dose adjustment by 22.35%.

Conclusions

It was concluded that grid ratio of 1:6 was capable of producing optimal radiographic contrast with a minimal radiation dose.

Keywords: Radiography Grid, Limitation, Radiation Dose

INTRODUCTION

There are several factors that can affect the amount of scattering radiation, namely the tube voltage (kV), tube current (mA), thickness or volume of the object and the area of the X-ray beam. Theese factors affect the contrast of radiographic images, because radiographic contrast is inversely proportional to scattering radiation. This pattern less scattering radiation can reduce radiograph contrast. Scattering radiation can be prevented from reaching the image receiver so that it can increase the radiograph image that is by using a grid (Bushong, 2011). Grid is a radiological examination aid consisting of plates or sheets of metal that have a high atomic number (usually lead) which are parallel between each other and separated by an insulating or inter-space material that can be penetrated by X-rays [1, 2]. The grid is the best tool for controlling scattering radiation. Grid has a structure consisting of two things namely inter-space material and grid material. In addition, the grid also has such characteristics namely grid ratio and grid frequency (Papp, 2011).

Grid ratio is the ratio between the thickness of the grid and the width of the inter-space material. Grid ratio values that are generally used in radiology are 1:5, 1:6, 1:8, 1:10 and 1:12. The selection of the grid ratio will affect the exposure factor that will be used in the inspection. The higher the value of the grid ratio, the higher the exposure factor that is used thus the higher the radiation dose received by the patient (Bushong, 2011).

Based on one of the principles of radiation protection, namely the principle of limitation, the use of nuclear power that requires exposure to radiation originating from an activity should be maintained as low as possible by considering various aspects. The purpose of the principle of limitation in radiation protection is that the use of radiation that can exposes the officers and the general public must be limited and must not exceed the established limit. This aims to produce low dose, both individually and collectively, and the minimum risk of unwanted exposure (Nuclear Energy Supervisory Agency, 2010). Based on the above explanation, the researcher intends to find a grid ratio that can produce optimal radiographic contrast with a minimum radiation dose [3, 4].

METHODS

This study used grid samples with ratios of 1:5, 1:6, 1:8, and 1:10. Grid was placed on a radiographic cassette, a container filled with water as high as 10 cm. was placed on it. A step wedge was placed in water 5 cm from the bottom of the container. Then the exposure was done with a variation in the tube voltage. Tube voltage values used in this study were 70 kV, 75 kV, 80 kV, 85 kV, 90 kV and the radiation dose was measured. The imaging plates were processed using a computed radiography device. The resulting images were printed without changing the existing image quality parameters [5, 6].

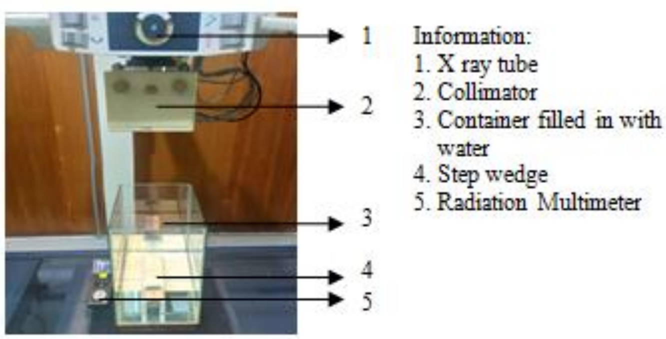
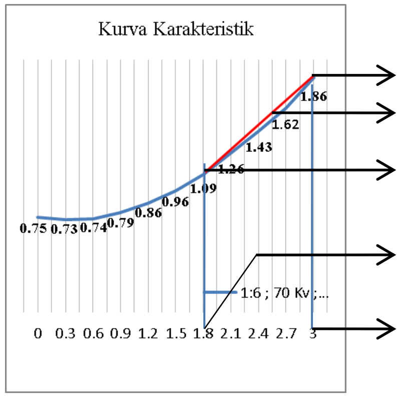


Figure 1. Data Collection

Figure 2 Radiograph on a 1:6 Grid Ratio and 75 kV Tube Voltage

The radiograph was measured its density at each step dor three times and the average value was calculated. A characteristic curve on was made from the density of each step. Furthermore, gamma value was calculated which described the contrast of the radiograph. The gamma value was calculated from the straight line curve [7].



Information:
1. D_1 value
2. Straight Line Area
3. D_2 value
4. Log Relative Exposure Value 1
5. Log Relative Exposure Value 2

Figure 3 Characteristic Curve for a 1:6 Grid Ratio with 70 kV Tube Voltage

Furthermore, the gamma value was calculated by the equation

$$\text{Gamma} = \frac{D_2 - D_1}{\log RE_2 - \log RE_1}$$

Information

D_1: The lowest density on the straight line
D_2: The highest density on the straight line
log RE_1: log relative eksposure value on the lowest density on the straight line
log RE_2: log relative eksposure value on the highest density on the straight line

Furthermore, an analysis was performed with a statistical test which included a correlation test between grid ratio and gamma value, a gamma value difference test, and a regression test for determining the radiation dose to produce the same deviation index.

RESULTS AND DISCUSSION

The results showed the gamma values for different grid ratios as shown in table 1 below:

Table 1 Gamma Values on Different Grid Ratios

No	Grid Ratio	Gamma
1	1:5	0.463
2	1:6	0.534
3	1:8	0.543
4	1:10	0.540

The results of radiation dose measurement based on tube voltage variations are shown in table 2 below:

Table 2 Radiation Doses based on X-Ray Tube Voltage Variations

No	**Tube Voltage** (kV)	**Radiation Dose** (µGy)
1	70	321,60
2	75	380.76
3	80	441.33
4	85	498.96
5	90	554.93

The results of the deviation index from the exposure index on tube voltage variations are shown in table 3 below:

Table 3 Deviation Index on Different X-ray Tube Voltages and Grid Ratios

No	Tueb Voltage (kV)	Rata-Rata Indeks Deviasi pada			
		Grid ratio of 1:5	Grid ratio of 1:6	Grid ratio of 1:8	Grid ratio of 1:10
1	70	-4.88	-5.16	-6.13	-6.65
2	75	-3.13	-3.45	-4.35	-4.87
3	80	-0.95	-1.35	-2.45	-2.57
4	85	0.26	-0.16	-1.4	-1.58
5	90	0.85	0.46	-0.71	-0.42

First, a Spearman correlation test was performed between the grid ratio and the gamma value. The test results showed that there was a significant correlation ($p < 0.05$) between the grid ratio used and the resulting gamma value. The correlation was positive or directly proportional, meaning that if the value of the grid ratio was increased, the gamma value also increased, and vice versa. However, the correlation between the grid ratio and gamma value was weak ($r < 0,5$).

Furthermore, a difference test on gamma value was conducted for each grid ratio. The gamma value in grid 1:5 shwoed that a significant difference ($p < 0.05$) with the gamma value in grid ratios of 1:6, 1:8 and 1:10. The gamma value in the grid ratio of 1:6 was not significantly different from the gamma values in the grid ratios of 1:8 and 1:10 ($p > 0.05$) meanwhile; there was no significant difference ($p > 0.05$) between the gamma values on the grid ratios of 1:8 and 1:10

After that, a regression test was conducted to obtain the tube voltage and the resulting dose at the same deviation index (-0.41) and the data generated are shown in table 4 below:

Table 4.Tube Voltage and Radiation Dose at Deviation Index of -0.41

No	Grid Ratio	Tube Voltage	Radiation Dose
1	1:5	83 kV	437.14 µGy
2	1:6	84 kV	485.34 µGy
3	1:8	93 kV	593.79 µGy
4	1:10	90 kV	557.64 µGy

The results showed that there was a significant correlation between the grid ratio and the increase in radiographic contrast ($p=0.001$). However, this correlation was not strong enough ($r = 0.427$). This is in accordance with the theory proposed by Bushong (2011), that there was a relationship between the grid ratio and the quality of the radiographis, and t study could explain the level of correlation conveyed by the theory. Less strong correlation between the grid ratio and the radiograph contrast was due to an insignificant difference when the grid ratio was increased from 1:6 to 1:8 ($p=0.509$) and from 1:8 to 1:10 ($p=0.888$). The difference only occurred when the grid ratio was increased from 1:5 to 1:6 ($p=0.000$).

The further analysis was to find out the correlation between the grid ratio and the change in radiation dose caused by the tube voltage adjustment. According to Bushong (2011), the higher increase in the value of a grid ratio that, the more the radiation to be absorb by the grid so that it will require a higher exposure factor. Based on the results of this study, to get the same deviation index from such increase (this study used a deviation index of -0.42) required compensation of the increase in tube voltage. Increasing the tube voltage automatically causes an increase in the radiation dose produced. In a grid ratio of 1:5, a deviation index of -0.42 could be obtained at a tube voltage of 83 kV which produced a radiation dose of 437.14 µGy while a grid ratio of 1:6 required an 84 kV tube voltage which produced a dose of 485.34 µGy. It can be seen that increasing the grid ratio from 1:5 to 1:6 increased the dose by 48.20 µGy or 11.03%. The change of grid from 1:6 to 1:8 caused an adjustment of the tube voltage from 84 kV to 93 Kv. The tube voltage adjustment resulted in an increase in radiation dose from 485.34 µGy to 593.79 µGy or there was an increase of 108.45 µGy equivalent to 22.35%. The change of grid ration from 1:8 to 1:10 caused an adjustment of the tube voltage value from 93 kV to 90 KV. The tube voltage adjustment resulted in a reduction in the radiation dose from 593.79 µGy to 557.64 µGy or a decrease of 36.15 µGy equivalent to 6.09%. The results showed that there was a comparable relationship between the increase in grid ratio and the radiation dose due to the tube voltage adjustment.

The above data showed that increasing the grid ratio from 1:5 to 1:6 could significantly increase radiographic contrast from the gamma value of 0.463 to 0.534, but the radiation dose would also increase by 11.03%. However, increasing the grid ratio from 1:6 to 1:8 or 1:10, the radiograph contrast did not increase significantly but the radiation dose would also increase. The correlation is in line with the proposition stated by Bushong (2011) on the correlation between the grid ratio with contrast and dose. In addition, this result also illustrated that the increase in the grid ratio did not always increase the radiograph contrast significantly, especially at ratios above 1:6

The increase in radiation dose becomes a real consequence as a consequence of the increase in the grid ratio, so in choosing the appropriate grid ratio we need to consider the radiograph contrast produced. Therefore it can be concluded that 1:6 was a grid ratio that is able to produce optimal radiographic contrast with a minimal radiation dose, since increasing the grid ratio from 1:6 to 1:8 or 1:10 did not significantly increase the contrast, otherwise could increase the radiation dose to the patient.

Health service institutions need to consider the use of grid ratios in conducting radiographic examinations. As an application, if a radiology installation has grids with different ratios of the same size, it is better to use a grid with a smaller ratio. In addition, in the process of radiological equipment procurement, especially grids, it is necessary to consider the ratio value. A grid ratio of 1:6 is the best choice because it was evidenced to produce an optimal image contrast with a lower dose than grids with ratios above it. Choosing the right equipment is an effort to implement the principle of protection, especially regarding dose limitation.

CONCLUSIONS

A grid ratio of 1:6 was capable of producing optimal radiographic contrast with a minimal radiation dose, since inceasing the grid ratio from 1:6 to 1:8 or 1:10 did not significantly increase the contrast, otherwise could increase the radiation dose to the patient.

REFERENCES

[1].American Association of Physicists in Medicine. An Exposure Indicator for Digital Radiography, 2009.

[2].Bapeten, PeraturanBadanPengawas Tenaga Nuklir, Tentang Keselamatan Radiasi dalam Penggunaan Pesawat Sinar-X Radiology Diagnostics Dan Interventional, 6, 2010.

[3].Bushong, S, .Radiologic Science For Technologists Physics, Biology And Protection. Mosby: USA, 2013.

[4].Hiswara, Eri. Buku Pintar Proteksi Dan Di Rumah Sakit, BATAN Press: Jakarta, 2015.

[5].Papp, J, Quality Management in the Imaging Sciences. CV. Mosby, Inc. St. Louis Missouri: USA, 2011.

[6].Sprawls, Perry. Physical Principle of Medical Imaging. An Aspen Publication, 1985.

[7].Steven D, Bruce R, Lois J, dan Bruce K. New Exposure Indicators for Digital Radiography Simplified for Radiologists and Technologists. American Journal Roentgenology, 2012.

How to cite this article: Fadli Felayani, Siti Rosidah, Daniel Manurung. Limitation of radiation dose exposure with the selection of radiography grid ratio. Int J of Allied Med Sci and Clin Res 2020; 8(2): 294-298.

Source of Support: Nil. **Conflict of Interest:** None declared.