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THE EFFECT OFF X-RAY GENERATOR VOLTAGE AND CURRENT ON DIGITAL IMAGE RADIOGRAPH

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ABSTRACT

Was conducted research to analyze the effect of voltage and current X-ray generator in the digital radiograph images . A baby phantom and head phantom object are used in this research. In this research using X-ray generator which is connected to the computer with the software Dr. Grabber 2012 at 70 kV voltage, filament current of 150 mA, exposure time of 0.5 s and 80 kV voltage, filament current of 150 mA, exposure time of 0.5 s. Digital radiographic image is processed using the Software Dr. Imager and analyzed using ImageJ software.

The results showed that: (1) Increase the voltage anode-cathode tube X-ray generator on the filament remains cause digital radiographic image produced tend to be darker. The reason to keep the filament current , the number of electrons that make up a cloud of electrons tend to remain. But due to the increase in anode-cathode voltage , energy of electrons striking the anode and produce high-energy X-rays to be larger. Consequently both phantom objects become more transparent and so is the interaction of X-rays with less sensitive detectors. This is the reason for the use of X-ray voltage at 70 kV, 150 mA is better than the use of X-ray voltage at 80 kV, 150 mA. It also gives the advantage of electric energy saving, reduction of radiation dose and radiation risk rate when using X-ray voltage is lower. (2) the relative decrease in gray level for baby and head phantoms, is very significant when the uses at 70 kV voltage, 150 mA to 80 kV, 150 mA . This can be showed from the difference in the gray levels in the parts of baby phantom as follows: (1) cheek 82 ± 5; (2) upper right arm 86 ± 2; (3) right lung 77 ± 7; (4) heart 81 ± 13; (5) liver 91 ± 7; (6) colon 88 ± 4; (7) stomach 88 ± 4; and (8) right thigh 89 ± 2. Similarly, the relative decrease gray level value of the head phantom to the parts: (1) forehead 36 ± 6; (2) Connection head left 32 ± 6; (3) Nose 25 ± 8; (4) right jaw 28 ± 5; (5) chin 36 ± 4.

Key Word: Voltage, Current Filaments, Digital Radiography

INTRODUCTION

X-rays used in medical as an attempt to diagnose or determine the internal parts of the body are medical disorders [1] .The trend of sophisticated digital technology, efforts to produce a digital radiograph was performed , either by direct digitazation radiographic film or perform digitization using digital imaging devices such as Direct Digital Radiography (DDR) .

Digital can be presented in a variety of visual media with the integrated electronic or information technology systems . Analysis of digital data or profile analysis can be performed with image analysis software , as it has been developed in the laboratory of image Physics , be it image analysis , histograms and line profiles . Image analysis is done to see the value of the degree of gray (image optical density) at various positions of pixels in the image, the area, and the area boundary. Histogram analysis performed for the analysis of the frequency distribution of the degree of gray (gray level) image . Line profile analysis was done by plotting the gray level at a particular pixel position [2].

In the operation of the X-ray generator, the operator aims at providing security to minimize the effects of X-ray radiation is to regulate the generator voltage, filament current and a low exposure time. This is in accordance with the principle of ALARA (as low as reasonable achievable). Thus when the digitization process efficiently the generator voltage, filament current, and time of exposure can be made lower.

1. X-RayTube

X-ray tube consists of a cathode and anode elements. Between the cathode and anode are given a high voltage, the electrons will be interested and hit the anode, thus producing X-ray. The higher the filament, the more the number of electrons is formed. The more the number of electrons are drawn toward the anode as a result of the use of high voltage (VA) between the anode and the cathode, the higher the intensity of light produced. X-ray intensity is proportional to the filament current and inversely with the square of the voltage VA [3].

The higher voltage applied to the anode , the greater the energy possessed by the electrons. Energy electrons when mashing the anode can be expressed in equation (1).

$$Ee = e\,V_A \; ; \qquad (1)$$

e is the elementary charge (e = 1.602 x 10-19 coulombs) , *Ee* is the electron energy , and VA is the anode voltage . When electrons collide with atoms of the anode , the resulting X-ray photons with an energy of Ep , according to the equation (2) .

$$Ep = hf \; ; \qquad (2)$$

where h is Planck's constant (h = 6.625 x 10-34 Js) and f is the frequency of the photon [4].

2. X-ray interaction with matter.

X-rays interact with matter will experience various events weakening . Size that can be used to express the amount of attenuation is known as attenuation coefficient or coefficient of absorption . When the absorption coefficients are expressed in cross section per electron is called the linear absorption coefficient and the density of atomic absorption cross section is called the mass absorption coefficient .

When an X-ray intensity are actually perfectly collimated magnitude *I* pass an absorbent material with absorption coefficient μ, with thickness *dx* radiation there will be a weakening of *dI*, and satisfies the equation (3).

$$dI = -\mu I dx \; . \qquad (3)$$

3. Film Radiography

Digital radiography techniques developed in line with advances in computer technology. Conventional radiographs using film or a fluorescent screen is analogous to the possibility of further analysis is very limited, which can not be improved image quality (contrast). In contrast, digital radiography techniques can be improved image quality within a certain accuracy limits due to quantization effects and numerical errata .

4. Radiograph parameter.

Radiograph image is determined by several parameters which are [5]:

a. Voltage generator / kilovoltage (kV). Effects kV to X-rays is that the high and low kV affects the quality of radiation and penetrating power of X-rays. The stronger the higher kV X-ray permeability of the material and vice versa. It is expressed by equation (4)

$$I \alpha V^2 \; . \qquad (4)$$

b. Miliamper seconds (mAs). Miliampersecon a multiplication between meliamper and time exposure. This mAs affect the quantity of X-rays are radiated per unit time. The quantity of X-rays is determined by the number of electrons per unit time from the cathode to the anode to reach the target atom. With the current rise can increase the number of electrons that fell to the anode so that X-ray photons produced more and more. The X-ray intensity I is formed proportional to the tube current *i*, as expressed in equation (5) .

$$I \alpha i \; . \qquad (5)$$

c. Distance irradiation .

Distance irradiation affects the magnification of the image size, image sharpness and image distortion. Changing this distance will affect the image of the irradiation. The X-ray intensity I is inversely proportional to the square of the distance between the object and the X-ray source *d*, according to equation (6).

$$I \alpha \frac{1}{d^2} \qquad (6)$$

d. The density of the material .

This type of material is irradiated will determine the image quality of radiographs, if the material has the same thickness, the magnitude of the density figures will determine the intensity of the X-ray attenuation after penetrating the material. The greater the density of the material, the greater the number of X-ray intensity attenuation.

5. Digital Image

Imagery is a continuous function of light intensity f(x,y) in a two-dimensional plane, where x and y denotes a coordinate, while the value of *f* at each point (x,y) expressed the intensity or " brightness ", or gray levels represent a certain physical quantities. A digital image is a continuous image that is converted into a discrete form, both the coordinates and the light intensity value. A digital image can be considered as a matrix of rows and columns where the index stating the coordinates of a point on the image and value of each element declares the light intensity f(x,y) at the point [6] .

The image is divided into small areas called image elements or pixels. Usually expressed as sampling lines box. The image is divided into horizontal lines composed of adjacent pixels. At each pixel location, the image pixel is sampled and quantized in order to obtain the level of brightness image at the point in question. Furthermore, the image presented by a series of boxes filled with integers. Each pixels having location (row number and column number) and the number of degrees of gray level. Digital data can be processed by a computer image [7] .

An image stored in the m-bit dynamic resolution format. When an image is presented with a size M rows and N columns, then the size of the digital image will be B bits or B / 8 bytes , which is expressed by

$$B = M \times N \times m .$$

Presentation Digital Image

In the analysis of the image there are several parameters that are used, namely the contrast, sharpness, and brightness. Contrast is the difference that makes a visual representation of the object can be distinguished from other objects and the background. The contrast can be observed quantitatively by wide variations in the gray levels in the image shown through histogran the degree of gray image. The sharpness of the image is a parameter that indicates the degree of brightness is good for coarse and fine object detail, as indicated by the ability to detect the edges of objects , and the ability to distinguish one part of the object with the other parts of the digital image [8]. Brightness is a visual perception is a subjective attribute of the object being observed. High and low brightness of the image can be seen in the image histogram.

METHODS

1. Materials Research
   Materials used in this reseach are:
   a. baby Phantoms
   b. head Phantom
2. Research Tools
   The equipment used in this research are:
   a. A set of Digital Radiography
      Digital radiography equipment used in this study was developed by digital radiography Grup Riset Fisika Citra (GRFC) Gadjah Mada University of Yogyakarta. The device has a digital radiography system main components, namely the control panel, X-ray source, flurosense screen, CCD camera, framegrabber, and computer equipment with Dr. Grabber 2012 software and based data analysis Dr. imager and ImageJ software.
   b. Control Panel.
      Working system X-ray tube is regulated by the control panel which serves to adjust the size of the X-ray energy to be fired. On the control panel there are several keys that must be set in advance, which is a key regulator of voltage (kV), a key regulator of current (mA) and a self-timer button (s), and there is a reset button in case of overload. X-ray source tube fused with light control unit serves to focus X-rays at a predetermined object. A computer with a program Dr. Grabber 2012 acts as a controller in the process of image acquisition and image processing based Dr. imager and ImageJ..

RESULT AND EXPLANATION

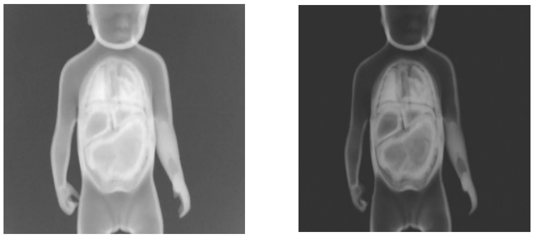
In the first research carried out by varying the voltage generator with 50 kV, 60 kV, 70 kV, 80 kV, 90 kV, and 100 kV. At the generator voltage of 50 kV and 60 kV X-ray energy absorbed by the material so it does not get to the detector, the resulting white image, Similarly, when the voltage generator 90 kV and 100 kV, energy X-rays that occur very high, causing the resulting radiograph image darker. Thus the voltage variation in this study presented image is the image of the radiograph at 70 kV and 80 kV voltage.

In this research, a strong variation of the flow also made strong currents of 100 mA and 150 mA. When used in current 100 mA resulting image showed no image appears. 100 mA current control panel is damaged. Thus, in this study used the results of the current image of the strong currents of 150 mA.

1. Analysis Baby Phantom

The following image was obtained using X-ray generator equipment that is connected to the device and the computer generated digital radiography developed Grup Riset Fisika Citra (GRFC) with the generator voltage at 70 kV and 150 mA filament current, and 80 kV and 150 mA filament current with time 0.5 second exposure. In a one-time exposure to X-ray digital radiography using Dr. Grabber 2012 produced 20 images within 0.5 second. The twenty image produced is then processed by software Dr. imager. Dr. imager is used to determine the best image among the twenty digital radiographic image output to be analyzed further.

Image in Figure 1 (a) is the best radiographic image at 70 kV voltage and current of 150 mA is generated by Dr. Imager software.



(a) (b)

Figure 1. The best digital radiographic image baby phantoms in the voltage (a) 70 kV and 150 mA filament currents. (b) 80 kV and 150 mA filament currents .

Processed images with Dr Imager Software produces 4 output images and retrieved one of the best image to be processed with ImageJ software. Observation area or Region of interest (ROI) is determined independently, in this study the size of 16 pixels wide and 19 pixels high for the selected part.

The results of measurement analysis using ImageJ software obtained information about the gray level at each sample parts: (1) cheek ; (2) upper right arm ; (3) right lung (4) heart; (5) liver ; (6) colon; (7) stomach; and (8) right thigh .for voltage 70 kV and 150 mA filament current and exposure time of 0.5 s was obtained information as in Table 1 .

Figure 1 (b) is the best radiographic image at a voltage of 80 kV, 150 mA current, the mean image output generated by the software Dr. imager. The results measurement analysis of image Figure 2 (b), by using ImageJ software obtained information about the gray level of each part: (1) cheek; (2) upper right arm; (3) right lung (4) heart; (5) liver; (6) colon; (7) stomach; and (8) right thigh, for a voltage of 80 kV and 150 mA filament current and exposure time of 0.5 s was obtained information as in Table 2.

Tabel 1 The result of measurement analysis of baby phanthom using ImageJ sofware at 70 kV voltage and 150 mA filament current

Part	X	Y	Area (pixel)	Min	Max	Median	Mean	Std Dev
Cheek	297	52	304	125	140	133	134	3
Upper right arm	197	192	304	138	146	140	140	2
Right lung	269	210	304	231	246	239	240	4
Heart	345	211	304	223	245	237	236	6
Liver	273	286	304	184	196	189	189	3
Colon	279	363	304	197	204	200	200	2
Stomach	354	354	304	201	206	203	203	1
Right thigh	253	507	304	148	15	149	149	1

Table 2 The result of measurement analysis of baby phanthom using ImageJ sofware at 80 kV voltage and 150 mA filament current

Part	X	Y	Area (pixel)	Min	Max	Median	Mean	Std Dev
Cheek	297	52	304	49	57	52	52	2
Upper right arm	197	192	304	53	57	55	55	1
Right lung	269	210	304	152	167	163	163	3
Heart	345	211	304	138	162	158	155	7
Liver	273	286	304	91	109	98	98	4
Colon	279	363	304	109	118	111	112	2
Stomach	354	354	304	111	121	116	115	2
Right thigh	253	507	304	56	63	60	60	1

If the comparison between the mean gray level of the digital image on a baby phantom voltage 70 kV, 150 mA to 80 kV, 150 mA for parts : (1) cheek ; (2) upper right arm ; (3) right lung (4) heart ; (5) liver ; (6) colon; (7) stomach ; and (8) right thigh, can be displayed as a graph in Figure 2.

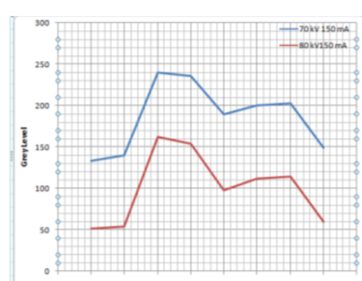


Figure 2. Display Gray Level at 70 kV 150 mA and 80 kV 150 mA for parts: (1) cheek ; (2) upper right

arm; (3) right lung (4) heart ; (5) liver ; (6) colon; (7) stomach ; and (8) right thigh.

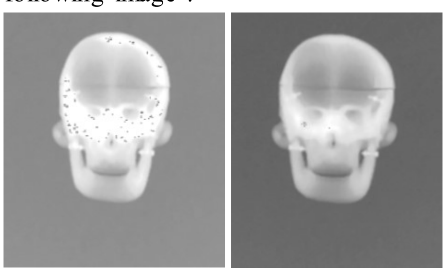
The results of mean gray level subtraction baby phantom for parts (1) cheek ; (2) upper right arm ; (3) right lung (4) heart ; (5) liver ; (6) colon; (7) stomach ; and (8) right thigh at a voltage of 70 kV, 150 mA filament current and voltage of 80 kV, 150 mA filament shown in Table 3.

Table 3 Results of mean gray level of the sample subtraction baby phantom in voltage at 70 kV, 150 mA and 80 kV, 150 mA

no	Parts	Subtraction of mean gray level
1	Cheek	82 ±5
2	Upper right arm	86 ± 2
3	Right lung	77 ± 7
4	Heart	81 ± 13
5	Liver	91 ± 7
6	Colon	88 ± 4
7	Stomach	88 ± 4
8	Right thigh	89 ± 2

Analysis the head Phantom

Phantom image acquisition heads like measures infant phantom image acquisition and obtained the following image .



(a) (b)

Figure 3. The best digital radiographic image on the head phantom voltage (a) 70 kV and 150 mA filament current , (b) 80 kV and 150 mA filament current

The results of measurement analysis of digital image head phantom using ImageJ software obtained information about the gray level at several positions: (1) right forehead; (2) connection head left; (3) nose; (4) right jaw; (5) chin, at voltage 70 kV and 150 mA filament current and exposure time of 0.5 s was obtained information as in Table 4

Tabel 4 The Results of measurements analysis using ImageJ software for head phantom at voltage 70 kV 150 mA

Part	X	Y	Area (pixel)	Min	Max	Median	Mean	Std Dev
Right forehead	315	247	400	177	188	184	184	3
Connection head left	415	249	400	191	255	233	233	16
Nose	339	333	400	0	255	247	237	33
Right jaw	289	377	400	143	229	222	213	20
Chin	335	410	400	182	196	189	190	2

The results of measurement analysis of digital image head phantom using ImageJ software obtained information about the gray levels in several parts: (1) the right forehead; (2) the connection head left; (3) the nose; (4) the right jaw; (5) chin. to voltage 80 kV and 150 mA filament current and exposure time of 0.5 s obtained the information as shown in Table 5.

Tabel 5 The results of measurement analysis using ImageJ software for head phantom at voltage 80 kV 150 mA

Part	X	Y	Area (pixel)	Min	Max	Median	Mean	Dev std
right forehead	315	247	400	141	154	148	148	3
connection head left	415	249	400	151	224	203	21	16
Nose	339	333	400	131	251	217	212	22
right jaw	289	377	400	105	202	191	185	20
Chin	335	410	400	147	161	154	154	2

If the comparison between the mean gray level of the digital image a baby phantom at 70 kV to 80 kV 150 mA and 150 mA for part: (1) right forehead; (2) connection head left ; (3) nose; (4) right jaw ; (5) chin, can be displayed in the graph in Figure 4.

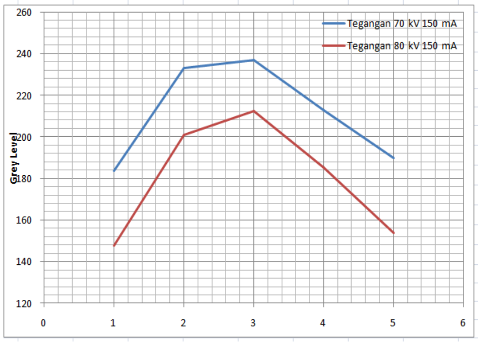


Figure 4. Display Gray Level at 70 kV 150 mA and 80 kV 150 mA parts: (1) right forehead; (2) connection head left; (3) nose; (4) right jaw; (5) chin .

The results of the mean gray level subtraction head phantom for part samples: (1) right forehead; (2) connection head left ; (3) nose; (4) right jaw ; (5) chin at a voltage of 70 kV, 150 mA and a voltage of 80 kV, 150 mA filament shown in Table 6.

Table 6. The results of mean gray level of the sample subtraction of head panthom at voltage 70 kV, 150 mA and 80 kV, 150 mA.

No	The sample	Subtraction of mean gray level
1	right forehead	36 ± 6
2	connection head left	32 ± 6
3	Nose	25 ± 8
4	right jaw	28 ± 5
5	Chin	36 ± 4

CONCLUSION

The increase in voltage anode - cathode X-ray generator in the filament remains cause digital radiographic image produced tend to be darker. The reason to keep the filament current, the number of electrons that make up a cloud of electrons tend to remain. But due to the increase in anode-cathode voltage, energy electrons striking the anode and produce high-energy X-rays to be larger . Consequently both phantom objects become more transparent and so is the interaction of X-rays with less sensitive detectors . This is the reason for the use of X-ray voltage of 70 kV, 150 mA is better than the use of X-ray voltage of 80 kV, 150 mA. It also gives the advantage of electric energy saving, reduction of radiation dose and radiation hazard rate when using lower X-ray voltage.

Relative reduction in gray levels for infants and phantom head phantom is very significant when the use of voltage70 kV, 150 mA to 80 kV, 150 mA. It can be seen from the difference in the gray levels in the parts of phantom baby as follows: (1) cheek 82 ± 5; (2) upper right arm 86 ± 2; (3) right lung 77 ± 7; (4) heart 81 ± 13; (5) liver 91 ± 7; (6) colon 88 ± 4; (7) stomach 88 ± 4 ; and (8) right thigh 89 ± 2. Similarly, the relative decline in the value of the gray level of the head phantom to the parts: (1) forehead 36 ± 6; (2) Connection head left 32 ± 6; (3) Nose 25 ± 8; (4) right jaw 28 ± 5; (5) chin 36 ± 4.

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