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Analysis of Size and Location of Irradiation Block of Electron Linear Accelerator to Radiation Output and Absorbed Dose

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Abstract**—***A research on the analysis of the field size and cerrobend block location effect at the electron beam output of Linear Accelerator for output radiation and absorbed dose. Measuring the output of the electron beam at each block location variations for each field size. Measurements using field size 4x10 cm^2, 5x8 cm^2, 8x15 cm^2, and 10x12 cm^2 for variation of block 1 to block 11. Output beam at block 1 and block 7 as the reference output data of the other block. The results showed that the radiation output at 5x8 cm^2 field size is greater than the output radiation of 4x10 cm^2 field size, as well as in 10x12 cm^2 field size produces output radiation that is larger than 8x15 cm^2 field size. These results indicate that the radiation field with an A/P greater the yield large radiation output. Extensive irradiation field equal to the value of A/P differently and produce output radiation absorbed dose is different. Radiation output at block radiation with a deviation of ≤ 2% can be recommended in clinical therapy for rectangular irradiation field. The measurement results for each different contexts in which radiation produces radiation output is different, the difference is obtained from the correction factor to determine the patient monitor units received on each layout block radiation. The resulting correction factor of 0.919 to 1.131 for block 2 through block 6 and 0.951 to 1.024 for the block 8 to block 11.*

Keywords**—***Block, electron, linear accelerator, output radiation, absorbed dose.*

I. Introduction

Radiotherapy is a type of therapy that uses radiation with high energy to kill cancer cells. Radiotherapy is done by giving a measurable dose of radiation to diseases such as tumors or cancer. Radiotherapy aims to destroy cancer cells, but can have a negative effect on healthy cells around it. Radiation damages cancer cells, so the process of multiplication or division of cancer cells is inhibited [1]. Planning treatment with radiotherapy methods attempted to minimize the negative effects on healthy tissue around the cancer. The process of radiotherapy is done by taking into account several aspects of cancer, cancer location, patient health, and the spread of cancer or metastasis [2].

The precise dose received by the patient is important in radiation therapy because a 7-10% dose change in target organ volume will result in a significant change in the probability of tumor control [3]. Determining the correction of the electron beam file monitor by using the same applicator field width with different block field area will result in a correction factor of different unit monitors, especially in low electron energies (4 MeV-6 MeV), while for relatively high energy stable 8 MeV-15 MeV) [4]. The field correction factor of the measurement and Monte Carlo calculations has a deviation of 2% for the shape of the circle field, semi-circle and square, whereas on the rectangular field there is a deviation of up to 4% [5].

The rectangular field on the electron beam can be formed by adding cerrobend blocks to the electron applicator. A rectangular field with the same field width but the location of blocks and different lengths of length produce different radiation outputs. Different radiation outputs produce different doses, so there is a correction factor for each block location variation.

From the existing problems and the results of previous research, it is necessary to measure the radiation beam output in determining the correction factor of the electron beam monitor to obtain the accuracy of the radiation dose in the target organ with the variation of the size and variation of the location of the irradiation block on the same square area of the rectangle

II. Materials and Methods

The research was conducted using Siemens Linear Accelerator production. Materials and equipment used include chamber ionization detector PPC 40. PPC detector placed in the middle of solid water phantom measuring 30 cm x 30 cm which is connected to the electrometer. The electrometer reads the output of the electron beam radiation and then calculates the deviation as well as the difference as a correction factor of the unit monitor (MU). Measurements were performed at room temperature 21^{0}C, humidity 35% and at 95.5 kPa air pressure.

Measurement data is used to analyze the effect of the size and location of the block on the irradiation of the electron beam, the difference of the electron beam output is necessary correction factor in order to get the correct dose on the TPS calculation. In this research using Linac applicator 10 x 10

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cm^2 and 15 x 15 cm^2 and used 100 cm SSD and PPC detector placed in mid solid water phantom at dmax point of data PDD (R_{100}) energy 5 MeV, 7 MeV, 8 MeV and 10 MeV.

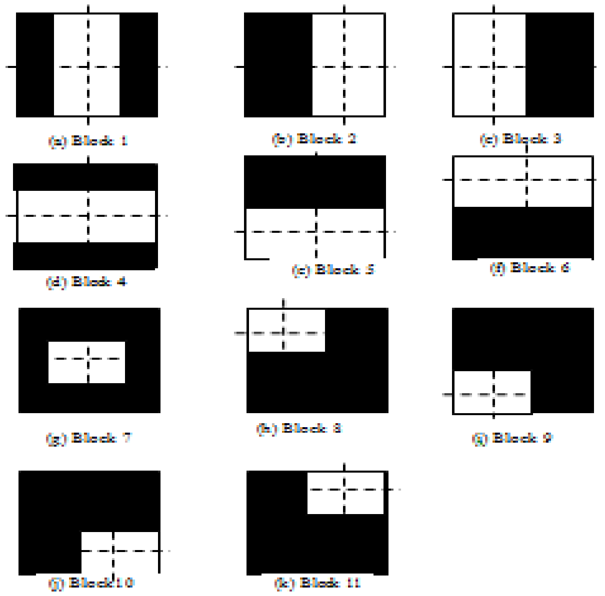

Fig. 1. Illustration of the variation of the location of the irradiation block.

The 10 x 10 cm^2 applicator is used on a 40 cm^2 irradiation field with 4 x 10 cm^2 and 5 x 8 cm^2 size variations. The 15 x 15 cm^2 applicator is used on a 120 cm^2 irradiation field with a size of 8 x 15 cm^2 and 10 x 12 cm^2 while for block location variations can be seen in Figure 1 (a to k). Block 1 and block 7 are used as reference data while blocks 2 through blocks 6 and blocks 8 to block 11 as variations.

III. Results and Discussion

Radiation output on field size variation

The radiation output of the irradiation due to block 1 and block 7 is used as reference data, since the phantom center point and the main axis of the beam come at the same point ie the center point of the phantom mass, so that the measured dose at that point is 100%. Figure 2 and Figure 3 show the radiation output graph and radiation dose on the electron beam energy due to the effect of field size variation.

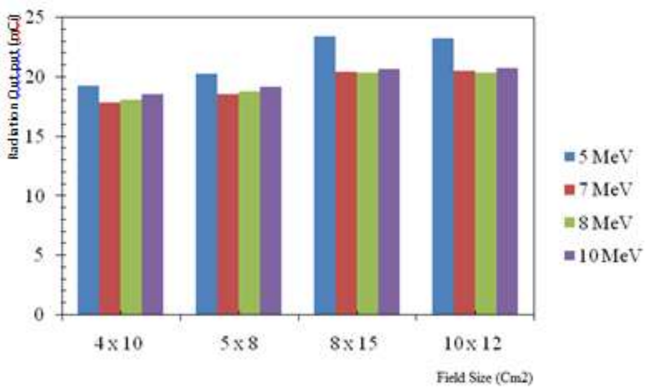

Fig. 2. Graph of the relationship between field size variation on the electron beam radiation output.

Figure 2 shows the electron beam radiation output on a variation in the size of the rectangular irradiation field. The 5 MeV electron energy file has the greatest radiation output compared to the other energy for the same field size and applicator area, this is because the 5 MeV energy has a relatively small maximum depth compared to the energy of 7 MeV to 10 MeV, so that the radiation received by the detector on the surface becomes larger. The energy of 7 MeV to 10 MeV produces an increasingly larger electron beam radiation output as the energy of the beam increases, this is because the deeper the penetration.

The absorbed dose of the electron beam is influenced by several factors, one of which is the electron beam quality correction factor (KQ, Q0). The 5 MeV electron energy file has a value of the correction factor of the beam quality of 1,055; file 7 MeV of 1.040; a 8 MeV file of 1,034; as well as the 10 MeV electron beam of 1,023.

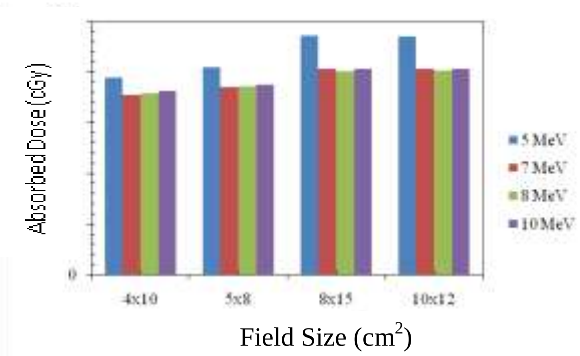

Fig. 3. Graph of the relationship between field size variations on doses of electron beam radiation.

In other words, the larger the beam energy the smaller the beam quality correction factor, this is because the more in R50 the electron energy used to interact with the targeting atom must be greater. The larger field of radiation causes an increase in the absorbing dose, this is due to the contribution of secondary electrons. The larger the field produces more secondary electrons, so the absorption dose that the detector receives gets bigger. Secondary electrons affect the spread of absorbent doses in phantom. Secondary electrons are generated by collisions between electron beam and atomic atom electrons (phantom) in the build up region. The collision causes the atomic electrons to absorb energy, if the absorbed energy is higher than its binding energy then the atoms are ionized. Electrons that come out due to the collision has a high speed and cause the increase in the dose build up area. The size of the irradiation field and the large A / P values result in a greater radiation output, so the higher the accepted absorption target dose

Radiation output on field 4 x 10 cm^2

The measurement of the radiation output of the electron beam is carried out at a 4 x 10 cm^2 field size for variations in the location of the block irradiation blocks 1 through block 6 (figure 1a to figure 1f), as shown in figure 4 . Table 1 shows the deviation of measurement results between block 1 and other block variations.

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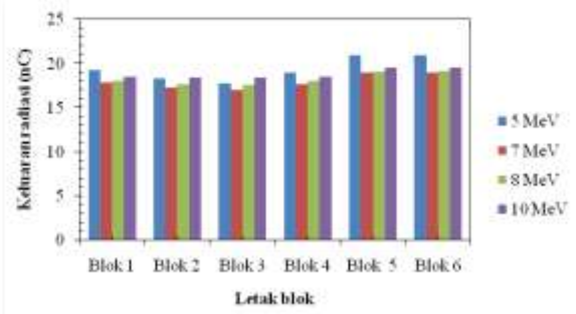

Fig. 4. Relationship graph of the variation of the location of the block to the radiation output on a field of 4 x 10 cm^2.

Figure 4 shows a graph of the relationship between the effect of variations in the location of the irradiation block and the electron beam energy on the output of the electron beam radiation with the same field size. Field 4 x 10 cm2 with 5 MeV electron beam energy irradiation occurs differences in radiation output due to the influence of block location variations of 1.348% - 8.709%. Measurement with 7 MeV electron beam source was a difference of 0.785% - 6.390%, while for 8 MeV electron beam was 0.442% - 5.973%, and for 10 MeV electron beam was 0.646% - 5.495%.

Irradiation due to block 4 produces a radiation output that approaches the reference block's radiation output, block 1 with a measurement deviation below 2% for all electron beam energies. The deviation shows that the irradiation location due to block 4 can be used as an alternative irradiation field in clinical applications.

TABLE 1. Deviation of radiation output measurement results on a 4 x 10 cm^2 field

Energy(MeV)	Deviation of electron beam output measurement results				
	Δ_{12} (%)	Δ_{13} (%)	Δ_{14} (%)	Δ_{15} (%)	Δ_{16} (%)
5	5,132	7,672	1,347	8,709	8,502
7	3,251	4,428	0,784	6,558	6,390
8	2,488	2,710	0,442	5,641	5,973
10	0,646	0,754	0,485	5,495	5,441

Radiation output at a field of 5 x 8 cm^2

Measurement of the radiation output of the electron beam is carried out on a field size of 5 x 8 cm2 for variations in the location of the block irradiation blocks 7 to block 11 (figure 1g to 1k), as shown in figure 5. Table 2 shows the deviation of measurement results between block 7 and other block variations.

Figure 5 shows a graph of the relationship between the effect of variations in the location of the irradiation block and the electron beam energy on the output of the electron beam radiation with the same field size. The 5 x 8 cm2 field with 5 MeV electron beam energy irradiation occurs due to differences in radiation output due to the influence of the block location variation of 3.887% - 5.068%. Measurements with a 7 MeV electron beam source had a difference of 3.653% - 3.976%, while for the 8 MeV electron beam were 3.131% - 3.980%, and for the 10 MeV electron beam was 3.539% - 4.320%. The results of the measurement of radiation output on a field of 5 x 8 cm2 due to the influence of the layout of the block location has a deviation of above 2% for all electron beam energies, so it needs to be corrected. The measurement deviation value is due to the placement of radiation blocks that are not in accordance with the irradiation field, resulting in leakage of electron beam radiation. Radiation leakage can be overcome by correcting the radiation output at each irradiation location, so that a correction factor is obtained for each location of the irradiation block. The radiation output in the irradiation block with a deviation of ≤ 2% can be recommended in clinical therapy in rectangular irradiation fields.

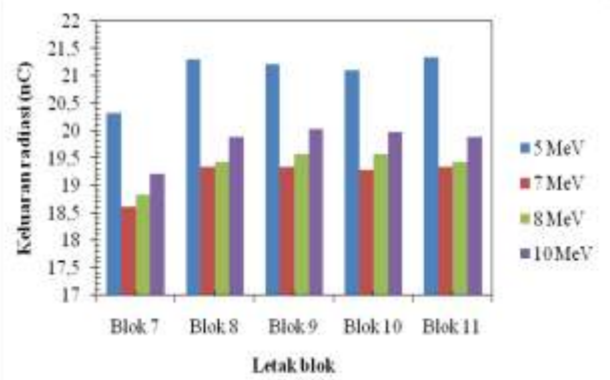

Fig. 5. Relationship graph of the variation of the location of the block to the radiation output on a field of 5 x 8 cm^2.

TABLE 2. Deviation of radiation output measurement results on a 5 x 8 cm^2 field

Energy (MeV)	Deviation of electron beam output measurement results			
	Δ_{78} (%)	Δ_{79} (%)	Δ_{710} (%)	Δ_{711} (%)
5	4,872	4,379	3,887	5,068
7	3,976	3,922	3,653	3,922
8	3,131	3,980	3,927	3,131
10	3,539	4,320	4,008	3,591

The radiation output is different for each variation of the location of the electron block irradiation block. The difference in the value of the radiation output at the same field size and radiation energy is caused by the spread of different doses at each point. Ideally the distribution or distribution of doses in one area should be the same in all irradiation positions, so that the dose received by the cancer is evenly distributed. The average beam energy is distributed higher in the middle and smaller at the edges. The location of the radiation block 5 produces the greatest radiation output compared to the location of the other blocks, while the smallest radiation output is produced by the 3 irradiation block location, for each variation of energy. The irradiation position determines the value of the radiation beam output, the greater the radiation output the higher the dose. Too large a dose causes damage to healthy tissue around the cancer.

Incorrect laying of blocks causes leakage of radiation files, causing unstable radiation output. Radiation leakage can be prevented by adding an irradiation field block that is appropriate and appropriate to the size of the desired irradiation field. The addition of a radiation block by placing a block on a different applicator level will cause a radiation leak, because the SSD used is different. Radiation leakage that reads the detector affects the radiation output, so that the radiation output that is read is not the actual radiation output.

IV. CONCLUSION

The results of the research that has been carried out, provide the following conclusions:

1. The area of the same irradiation field with different A / P values produces a different radiation output and absorbed dose.
2. Radiation output at the location of the irradiation block with a deviation of ≤ 2% from the reference data, can be recommended for clinical therapy for rectangular irradiation fields.
3. The measurement results for each difference in irradiation location produce a different radiation output, from the difference obtained a correction factor to determine the monitor unit (MU) size that the patient receives at each irradiation location.

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