VERIFICATION OF THE OUTPUT DETERMINATION OF 12 MEV ELECTRON BEAM FROM AN ELEKTA VERSA HD/154714 LINEAR ACCELERATOR MACHINE AT MAYAPADA HOSPITAL

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ABSTRAK

VERIFIKASI PENENTUAN LUARAN BERKAS ELEKTRON 12 MEV PESAWAT PEMERCEPAT LINIER ELEKTA VERSA HD/154714 DI RUMAH SAKIT MAYAPADA. Makalah ini menguraikan verifikasi penentuan laju dosis serap air berkas elektron energi nominal 12 MeV yang dipancarkan dari pesawat pemercepat linier medik Elekta Versa HD/ 154714 milik Rumah Sakit Mayapada, Lebak Bulus, Jakarta. Pengukuran dilakukan di dalam fantom air *1D Scanner* pada kondisi acuan dengan jarak sumber radiasi ke permukaan air 100 cm dan lapangan radiasi yang dibentuk oleh aplikator 10 cm x 10 cm serta kedalaman yang sesuai dengan (0,6 R50 – 0,1) cm. Sebagai alat ukur radiasi untuk pengukuran PDD digunakan detektor ionisasi IBA CC13, sedangkan pengukuran absolut digunakan detektor ionisasi keping sejajar Roos yang dirangkaikan dengan elektrometer PTW Unidos Webline milik PTKMR-BATAN yang tertelusur ke laboratorium standar primer BIPM, Perancis dan detektor ionisasi keping sejajar IBA PCC40 yang dirangkaikan dengan elekrometer Dose 1 milik Rumah Sakit Mayapada yang tertelusur ke laboratorium standar primer PTB, Jerman. Perhitungan hasil pengukuran dilakukan menggunakan protokol dosimetri IAEA yang terdapat dalam Technical Report Series No. 398. Hasil yang diperoleh menunjukkan adanya kesesuaian yang cukup baik antara kedua pengukuran dengan perbedaan 0,3%.

Kata kunci: pesawat pemercepat linier elekta versa HD, berkas elektron, laju dosis serap air, verifikasi

ABSTRACT

VERIFICATION OF THE OUTPUT DETERMINATION OF 12 MeV ELECTRON BEAM FROM AN ELEKTA VERSA HD/154714 LINEAR ACCELERATOR MACHINE AT MAYAPADA HOSPITAL. *This paper describes verifying the determination of the 12 MeV nominal energy beam electron water absorption dose emitted from the Elekta Versa HD / 154714 medical linear accelerator owned by Mayapada Hospital, Lebak Bulus, Jakarta. Measurements were done in the 1D water phantom Scanner under reference conditions with the source to surface distance 100 cm and the standard field size using the applicator 10 cm x 10 cm and the depth corresponding to (0.6 R50 - 0.1) cm. The IBA CC13 ionization chamber was used as a radiation measurement instrument for PDD measurements, while the Roos plane-parallel ionization chamber was used for absolute measurements. Roos's parallel ionization chamber was connected with PTKMR-BATAN's PTW Unidose Webline electrometer. This ionization chamber was also traced to the primary standard laboratory of BIPM, France. Meanwhile, the PCC40 plane-parallel ionization chamber was connected with a Dose 1 electrometer owned by Mayapada Hospital, which was traced to the PTB primary standard laboratory. Calculation of measurement results was carried out using the IAEA dosimetry protocol contained in Technical Report Series No. 398. The results obtained indicate a fairly good fit between the two measurements with a difference of 0.3%*

Key words: electron beam, linier accelerator elekta versa HD, verification, water absorbency dose rate

INTRODUCTION

The role of the private sector in the development of the use of ionizing radiation, especially medical linear accelerators in Indonesia, began in 2017 with cooperation between investors from Singapore and the Adi Husada Hospital, Surabaya, which operates the Elekta Synergy Platform medical linear accelerator.

In 2018 the Elekta medical linear accelerator vendor in Taiwan CHC Healthcare collaborated with Mayapada Hospital, Lebak Bulus, Jakarta, to operate an Elekta Versa HD medical linear accelerator no. Series 154714. This machine has 6 and 10 MV photon beams and electron beams with nominal energies of 6, 9 and 12 MeV.

The principle of radiotherapy was the use of ionizing radiation to cure the cancer cells with a measured dose of tumor volume and minimize the effects of radiation on healthy tissue. Accuracy in administering doses to patients should not exceed ± 5% [1,2]. Based on the reason, the government for nuclear regulatory body requires the user to calibrate the radiation sources[3].

To get an accurate radiation dose for tumor patient irradiation, it needs to take several measurements of dosimetry. One of these dosimetry parameters was the percentage depth dose of the photon and electron beam from the linear accelerator used. Percentage depth dose (PDD) was needed to get the depth of water-absorbent dose rate measurement, radiation beam quality index, and a correction factor of the radiation quality used for calculation of absorbed dose to water [4].

The results of a measurement were influenced by several factors, including measuring instruments, personnel competency, supporting equipment, protocols, and environmental conditions. Current condition show the trend to involve independent parties (third parties) which have capabilities to ensure the results of measurement [5].

To apply the quality control program, Mayapada hospital has several radiation measuring instrument, such as IBA welhofer dosimeter that been used in relative measurement namely percentage of depth dose (PDD) and beam profile. For absolute dosimetry measurement, they used the FC65-G/2477 ionization chamber with 0.65 cm^3 volume for photon measurement, and plane-parallel PPC40/18186 for electron measurement.

To ensure the results of the determination of the absorbed dose to water, the verification of measurement by hospital medical physicist was also carried out. The measurements were taken using their dosimetry equipment for an electron beam with nominal energy 12 MeV. There were no special considerations regarding the choice of radiation quality of the electron beam above, except because the electron beam was the highest radiation quality.

This paper describes about the verification of the output determination of the 12 MeV electron beam from the an Elekta Versa HD/154714 medical linear accelerator at Mayapada Hospital, Lebak Bulus, Jakarta. Elekta Versa HD linear accelerator machine with serial number 154714 can be seen in Figure 1.

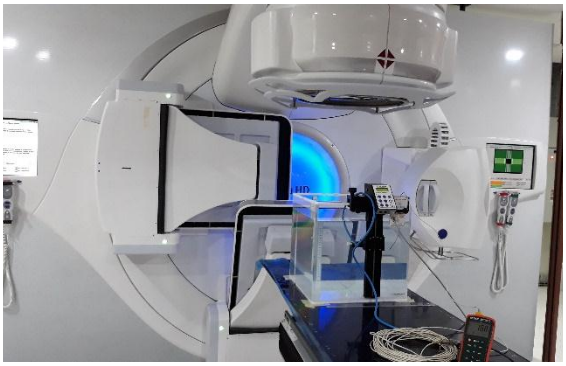

Figure 1. Elekta Versa HD Medical Linear Accelerator

Measurement of Percentage Depth Dose (PDD) Electron Beam

To get the percentage depth dose curve, it can be done using relative measurements. The dosimeter system for this relative measurement uses two detectors. The first detector was a reference that was placed fixed in the radiation field above water surface, while the second detector can be moved along the main axis starting from the surface of the water to the required depth [6].

Determination of the Absorbed dose to water Electron Beam

The absorbed dose to water of a medical linear accelerator was one of the essential dosimetry parameters because the success of the radiotherapy treatment was very dependent on this parameter [7]. The absorbed dose to water at the reference measurement point can be calculated using Eq. (1).

$$D_{w,Q} = M_Q \cdot N_{D,w,Qo} \cdot k_{Q,Qo} \qquad (1)$$

With,

$D_{w,Q}$	:	Absorbed dose to water at the reference measurement point
M_Q	:	Dosimeter readings were corrected for temperature, pressure and recombination of ions and polarity
$N_{D,w,Qo}$	:	Dosimeter calibration factor in the terms of absorbed dose to water for reference quality Q_0 (Co-60)
$k_{Q,Qo}$	:	The correction factor of the radiation quality of the detector used. Table 7.III in TRS No. 398 for electron beams

METHODOLOGY

Equipment

As a source of radiation, we used the Elekta Versa HD with serial number 154714. It has 6 and 10 MV photon beams and electron beams with nominal energies of 6, 9, and 12 MeV.

The radiation measuring instrument used by PTKMR-BATAN was a plane-parallel ionization chamber Roos TW 34001 with serial number 0125 for electron beam measurements. The detector was connected with a PTW Unidos Webline Electrometer T10022 s.n 268.

Table 1. Specification of detector ionization at aluminum IBA PPC40

Beam Quality	Nominal Energy Range	R_{50}	K_Q
Elektron	2–20 MeV	R_{50} 1.0– 8.0 cm	0.969 – 0.893

The radiation measuring instrument used by the Mayapada Hospital was a PPC40 plane-parallel ionization chamber s.n 1894 connected with the IBA Dose 1 electrometer s.n 26590. This dosimeter was traced to the PTB Primary Standard Dosimetry Laboratory, Germany. These PPC40 plane-parallel ionization chamber have not been listed in Table 7.III of the IAEA publication contained in TRS 398. However, the detector manuals include the K_Q values as presented in Table 1 below.

PTW Roos and PPC40 plane-parallel ionization chamber, PTW Unidos Webline and IBA Dose 1 electrometers can be seen in Figure 2 below.

(a) (b)

Figure 2. a) PTW Roos and IBA PPC40 ionization chamber b) PTW Unidos Webline and IBA Dose 1 Electrometers

Methods

The Measurement of 12 MeV Electron Beam Percentage Depth Dose

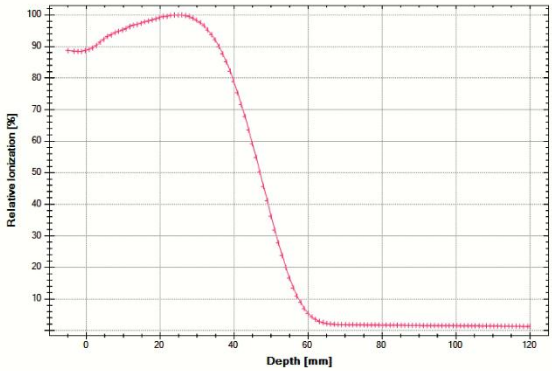

Figure 3. Percentage depth dose (PDD) of the 12 MeV electron beam at SSD100 cm, applicator 10 cm x 10 cm

The medical physicist measured the PDD of 12 MeV electron beam. Measurements were made using the IBA Welhofer Dosimeter system at the source to surface distance (SSD) 100 cm and the standard field size formed by the applicator 10 cm x 10 cm.

The first step, the detector was placed on the surface of the water, then irradiated with a 12 MeV electron beam. Then the detector will automatically moved along the main axis of the field size to the required depth. From this measurement, a percentage depth dose curve will be obtained in the nominal electron beam depth of 12 MeV whose results can be seen in Figure 3 below.

From Figure 3, the dose depth reaches 50% of the maximum value: R50 was 4.78 cm. By using the equation (0.6 R50 - 0.1) cm, the depth of measurement will be obtained to determine the the absorbed dose to water of 2.77 cm with a PDD at a depth of 99.61%.

The Measurement of The 12 MeV Electron Beam absorbed dose to water

Figure 4. The setting of the dosimetry equipment

After the depth of measurement was obtained, it was continued with the determination of absorbed dose to water using the plane-parallel chamber PTW Roos. The detector was placed at a depth of 2.77 cm at the SSD 100 cm and the field size formed by the applicator 10 cm x 10 cm. The detector was first irradiated for pre-irradiation. After that the detector was irradiated with a dose of 200 MU for 5 times data. Temperature and pressure during measurement were observed. The correction factors needed to be taken in Equation 1 were measured, such as the recombination and polarity correction factors.

Hospital Medical physicist has carried out the same step after PTKMR BATAN measurement was done. The measurement was carried out using their radiation measuring device. The setting of dosimetry equipment can be seen in Figure 4 below.

RESULT AND DISCUSSION

From the PDD curve in Figure 3 an R50 value of 4.78 cm was obtained, using Table 7. III in TRS No. 398 will be obtained the correction factor value of $K_{Q,Q0}$ for the PTW Roos in Equation 2 of 0.9138. For the IBA PPC40, the correction factor values of $K_{Q,Q0}$ for electron beams with R50 = 4.78 cm were obtained from the interpolation in Table 1 which obtained K_Q values, Q0 = 0.928.

Calculation results of measurements of the absorbed dose to water for 12 MeV electron beams using PTKMR-BATAN's ionization chamber can be seen in Table 2 below.

Table 2. Results of determination the absorbed dose to water using PTW Roos

Detector	PTW Roos-PTKMR
View (nC/200MU)	22.74
$N_{D,w}$ (mGy/nC)	83.84
K_s	1.0033
K_{pol}	0.9996
k_Q	0.9138
D_{reff} (cGy/200MU)	1747
PDD%	99.61
D_{max} (cGy/200MU)	1754

From Table 2 it can be seen that the absorbed dose to water at maximum dose depth get a value of 1754 mgy/200 MU, which means 1 MU ≈ 0.877 cGy. These results get a deviation of -12% of 1 MU ≈ 1.00 cGy.

Thus, it was necessary to adjust the linear accelerator to maintain the 1 MU ≈ 1.00 cGy. After adjutsment, measurements were made again, the results of which can be seen in Table 3 with 1 MU ~ 1.00 cGy. These results were in good agreement, also used as a reference for verification of measurement results made by Mayapada Hospital medical physicist using IBA PPC40 whose measurement results can be seen in the same table.

From Table 3, it can be seen that for a 12 MeV electron beam, Hospital medical physicist gets a value of 2007 mGy / 200 MU, while PTKMR gets a value of 2005 mGy / 200 MU. These results indicate an insignificant difference of 0.3%. Based on these differences, the results obtained were still within the maximum deviation limit, which was 3.5% [8].

Table 3. Comparation of measurement

Detector	Roos PTKMR	PPC40 RS Mayapada
View (nC/100MU)	25.991	24.45
$N_{D,w}$ (mGy/nC)	83.53	88.12
K_s	1.008	1.0028
K_{pol}	1.003	1.0003
k_Q	0.894	0.928
D_{reff} (cGy/100MU)	1997	1999
PDD%	99.61	99.61
D_{max} (cGy/200MU)	2005	2007

The uncertainty of the measurement results was evaluated according to the criteria contained in ISO / TAG 4 / WG 3: Guide to the Expression of Uncertainty in Measurement [9], which defines two categories of uncertainty components namely Type A and Type B 10. Components of type A uncertainty include: repeated readings of radiation measuring devices, ion recombination correction factors and polarity correction factors, while type B includes: uncertainty of the stability of the measuring instrument.

CONCLUSION

From the results of the discussion it can be concluded that there was a fairly good suitability of the absorbed dose to water determined by the PTW Ross plane-parallel ionization chamber of PTKMR BATAN and the IBA PPC40 plane-parallel ionization chamber of Mayapada Hospital.

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