Implementation Technique of Radiotherapy Patients Dose Verification 3DCRT and IMRT

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Abstract. The implementation of Patient Dose Verification Techniques 3DCRT and IMRT aims to guarantee that the dosing shines in accordance with planning the therapy conducted in TPS (Treatment Planning System). Research carried out using Variant types of Clinac CX in Radiotherapy Unit hospital Wahidin Sudirohusodo Makassar. Verify patient dose measurement is done using a dose point and a dose planar by taking 10 cancer patients cervix 3DCRT techniques and 10 engineering nasopharynx cancer patients IMRT. Results of the study 10 point dose cervix cancer patients techniques 3DCRT retrieved the deviation between -0.005% to 0.243%, an average deviation -0.234%, standard deviation -0.186, and CL 0.364. While in nasopharynx cancer patients IMRT technique obtained the deviation between -1.385% to 1.652%, an average deviation 0.146%, standard deviation 0.015, and CL 0.174. Dose planar measurement 10 samples of cancer patients cervix engineering 3DCRT retrieved gamma index 3% 3 mm on average of 97.26%, standard deviation 0.063, CL 2.772 and 2 mm 2% average 85.91%, standard deviation of 0.007, CL 15.17. While in nasopharynx cancer patient with IMRT techniques acquired gamma index 3% 3 mm average 97.00%, standard deviation 0.016, CL 3.03 and 2% 2 mm average 83.38%, standard deviation 0.016, and CL 16.65.

1. Introduction

Cancer is a disease that occurs due to uncontrolled cell growth that turns into abnormal cells and spreads to other body tissues [1]. In 2017 it is predicted that nearly 9 million people die worldwide due to cancer and will continue to increase to 13 million people per year by 2030. Radiotherapy is one of the main modalities in the treatment of cancer, about 50% of patients who receive radiotherapy, 30% of whom experience side effects [2]. The aim at radiotherapy is to provide radiation with a measured dose and appropriate tumor volume that has been established for eradication of tumors with minimal damage to healthy tissue around the tumor [3]. Treatment of tumors using ionizing radiation will kill malignant tumor cells so that no other tissue spreads occur [4,5].

International reporting data onto incidents of accidents on radiotherapy, related to teletherapy aircraft have occurred in parts of the world including in Indonesia. Accident cases of Linac (Linear Accelerator) radiotherapy starting from the radiation beam that came out were not as desired when it was about to illuminate the patient [4] besides the Linac TPS (Treatment Planning System) was one of the main sources of errors in radiotherapy. Planning accurate and precise dosing is very important to obtain tumor eradication and save healthy tissue from unnecessary radiation [6]. Dose verification radiotherapy allows for procedure testing and error identification [7]. In making accurate planning between the results of calculation of TPS doses with the 3DCRT technique and IMRT, verification must be done [8]. Provision of optimum doses of radiation radiotherapy is very useful to achieve successful treatment. Therefore it is necessary to verify patient dose as a function of quality control and quality assurance.

2. Experiment

The Linear Accelerator used in this study is the Clinac CX photon 6 MV variant, TPS Eclipse, Neuvis CT Simulator type DU5008C No. Series 79011 with the ability of 16 slices, phantom Slab dimensions 30 cm x 30 cm, Ion chamber, Octavius 2D Array, computer calibration and Verisoft Plan Verification software. The method used is a phantom slab scan by giving a marker for the midpoint, the right-left edge as a verification scan on the TPS computer, as well as the Octavius 2D Array, as shown in figure 1 (a) and (b).
Data from the phantom slab scan and Octavius 2D Array is sent to the TPS computer. Furthermore, the data was given a design protocol for irradiating cervical and nasopharyngeal cancer patients with 3DCRT and IMRT techniques according to the results of planning at TPS as shown in figures 2 (a) and 2 (c). CT scanned Octavius 2D array data is given a protocol to design irradiation of cervical cancer and nasopharyngeal cancer by making a gantry 0° angle. All rays are centered on the isocenter as shown in figures 2 (b) and 2 (d). The patient consisted of 10 cervical cancers in the 3DCRT technique and 10 IMRT nasopharyngeal cancers which would be verified by the accumulation of irradiation fields.

The data doses cervix cancer patients and cancer of the nasopharynx in TPS computer sent to Arya work station control room Linac, then performed a very to data retrieval was dose point in slab phantom with engineering Source of Surface Distance (SSD) 100 cm from the gantry and a dose plannar using a 2D array of Octavius engineering Source Axis Distance (SAD) 90 cm. Data obtained in the form of electric charges (nC). By using TRS, 398 readings are still in the form of raw data is then calculated to get the value absorbed dose to water using the following equation:

$$D_{w,Q} = M_Q N_{D,w,Q} k_{Q,Q_0}$$  \hspace{1cm} (1)

Where $D_{w,Q}$ is absorbed dose to water on the quality of the file Q (cGy), $M_Q$ is dosimeter readings are corrected (nC), $N_{D,w,Q_0}$ is the calibration factor of the detector and $k_{Q,Q_0}$ is the correction factors of the quality of the file [9].

Evaluation of dose point is done by calculating the deviations from the dose calculation of TPS with a dose measurement of slab phantom. The determination of the magnitude of the deviation from the recommended equations using IAEA TRS 430:

$$\delta = 100 \times \left( \frac{D_{cat} - D_{meas}}{D_{presc}} \right)$$  \hspace{1cm} (2)

Where $D_{cat}$ is dose calculation of TPS, $D_{meas}$ is the dose measurements of $D_{presc}$ is prescription dose [10].
3. Results and Discussion

Implementation verification of dose patients with 3DCRT techniques performed by the method of measurement of the dose point and dose planar on cases of cancer cervix obtained results in table 1.

Table 1. The Results of The Verification of Dose Point and Dose Planar of The Engineering Cervix Cancer Patients 3DCRT

| Patient | Dose Point (Gy) | Dose Planar gamma (1% < %) |
|---------|-----------------|----------------------------|
| TPS     | Counted        | Deviation 3% | Deviation 3mm | Deviation 2% | Deviation 2mm |
| 1       | 1,970          | 1,961        | -0.405        | 99.2         | 83.5          |
| 2       | 2,250          | 2,241        | -0.441        | 98.1         | 91.6          |
| 3       | 2,153          | 2,152        | -0.005        | 98.4         | 72.6          |
| 4       | 2,033          | 2,027        | -0.264        | 95.5         | 82.1          |
| 5       | 1,930          | 1,926        | -0.170        | 97.0         | 85.2          |
| 6       | 1,941          | 1,945        | 0.243         | 98.8         | 75.7          |
| 7       | 2,127          | 2,123        | -0.176        | 97.1         | 86.1          |
| 8       | 2,081          | 2,079        | -0.096        | 94.8         | 91.3          |
| 9       | 2,091          | 2,085        | -0.275        | 97.8         | 89.6          |
| 10      | 2,109          | 2,103        | -0.026        | 96.7         | 90.6          |
| Average Deviation | -0.234 | 97.35 | 84.83 |
| Deviation Standard (SD) | -0.186 | 0.063 | 0.007 |
| CL      | 0.364          | 2.772        | 15.178        |

Based on table 1, dose point in cancer patients cervix retrieved deviation from range -0.005% to 0.243%, average deviation -0.234, standard deviation -0.063 with CL 0.363 (within the tolerances recommended by the AAPM TG 119 of ± 5% with CL 0.47) [11] and the dose planar obtained dose gamma index 3% 3 mm average 97.26%, deviation 0.063, and CL 2.772, standard deviation 0.063, with CL 2.772. While the value of gamma indexes 2% 2 mm obtained average 85.91%, the standard deviation of 0.007 and CL 15.17. Each dose should not exceed the value of conformity shines allowed AAPM TG 119 that is 90% to 3% CL and 3 mm 12.4 [12], more details of the index gained gamma can be seen in Figure 3.

![Figure 3. The Results of The Verification of Dose Planar (Gamma Index) With 3DCRT Techniques in Cancer Patients Cervix)](image-url)
Based on table 2 doses of nasopharynx cancer patients at point retrieved the deviation from the range -1.385% to 1.652%, average deviation -0.234, standard deviation-0.186 with a CL of 0.364 (do not exceed the dose recommended by the AAPM TG 119 i.e. of ± 5% with CL 0.47) [13]. While a dose plannar retrieved gamma index 3% 3 mm on average 97%, standard deviation 0.016 and CL 3.034. In general, the implementation of patient Dose Verification with IMRT techniques in getting the dose point within the limits of tolerance or do not exceed the dose recommended by the AAPM TG 119 i.e. of ± 5% with 2% CL 0.47 and 2 mm average 83.38%, standard deviation 0.016, with CL 16.65. The value of the tolerance percentage gamma index of 90% to 3%, with 3 mm CL 12.4 [11], more details presentation gamma index can be seen in Figure 4.

| IMRT (Nasopharynx cancer) | Table 2. The Results of The Verification of Dose Point and The Dose Plannar of Nasopharynx Cancer Patients IMRT Techniques |
|---------------------------|---------------------------------------------------------------------------------------------------------------|
| Patient | TPS | Dose Point (Gy) | Deviation | Dose Plannar gamma (1<%) |
|---|---|---|---|---|
| 1 | 1,229 | 1,201 | -1,385 | 97.80 | 88.60 |
| 2 | 1,491 | 1,492 | 0.062 | 98.87 | 84.70 |
| 3 | 1,372 | 1,356 | -0.760 | 93.70 | 78.60 |
| 4 | 1,652 | 1,658 | 1,625 | 96.00 | 81.60 |
| 5 | 1,449 | 1,450 | 0.076 | 97.10 | 77.43 |
| 6 | 1,625 | 1,637 | 0.613 | 95.80 | 83.60 |
| 7 | 1,421 | 1,418 | -0.109 | 95.60 | 74.30 |
| 8 | 1,366 | 1,339 | -1.334 | 96.70 | 82.23 |
| 9 | 1,483 | 1,495 | 0.649 | 98.70 | 95.40 |
| 10 | 1,345 | 1,328 | -0.820 | 99.70 | 87.30 |
| Average Deviation | | | | -0.234 | 97.00 | 83.38 |
| Standard Deviation (SD) | | | | -0.186 | 0.016 | 0.016 |
| CL | | | | 0.364 | 3.034 | 16.65 |

Figure 4. The Results of The Verification of Dose Plannar (Gamma Index) and IMRT Technique on Nasopharynx Cancer Patients
In general, the two measurements showed good results, although underestimated dose measurements occurred, this was due to the use of small fields in the IMRT technique which caused no fulfillment of charged particle equilibrium due to a smaller field size than the electron distance from the lateral side resulting in lateral electronic disequilibrium [12-13]. The effect of volume averaging, chamber ionization size must be comparable or smaller than the size of the radiation field [11][15,16]. The dose planar obtained by gamma index 3% 3mm, each irradiation within tolerance does not exceed the permissible value of 90%. The wider the area and complexity of the target volume the smaller the gamma index value will be [13-14].

4. Conclusion
The results of the verification of the engineering cervix cancer patients dose 3DCRT using slab phantom and Octavius 2D array is retrieved point by dose range deviation -0.005% to 0.243%, average deviation -0.234, standard deviation -0.186 and CL 0.363. While a dose planar obtained conformity pixels above 90% with an average score of 97.26% at 3 mms and 3% CL 2.772. The results of the verification of dose of nasopharynx cancer patients IMRT technique using slab phantom and Octavius 2D array is retrieved point by dose deviation in range-1.385% to 1.652%, average deviation -0.234, -0.186 with a standard deviation from CL 0.364. Whereas dose planar obtained conformity pixels above 90% with an average score of 97.00% at 3%, and 3 mm CL 3.03. The second case shows the quality of the distribution of the dose given to a patient is in good condition.

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