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Evaluation of Heterogeneity and Conformity Index Using IMRT and VMAT Techniques in Breast Cancer

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ABSTRACT

One of the most prevalent cancers in both men and women is breast cancer. A number of choice therapy covers surgery, radiotherapy, chemotherapy, and hormonal therapy. Radiotherapy is typically used as a cancer treatment because it can eliminate cancer cells and aid in preventing cancer recurrence following surgery. Dose planning must be completed before irradiating the patient. Planning is carried out in a treatment planning system (TPS) with several available technique options. In this study, we chose intensity-modulated radiotherapy (IMRT) and volumetric-modulated arc therapy (VMAT) techniques. To determine the quality of the dose planning of these two techniques, a comparison of the heterogeneity index (HI) and conformity index (CI) parameters was carried out. The results of the comparison between IMRT and VMAT show that VMAT is superior to IMRT in terms of homogeneity and conformity. This is consistent with the HI results on VMAT showing a mean of 1.060 while IMRT shows a mean of 1.081. In addition, the CI results at VMAT showed a mean of 0.641 while IMRT showed a CI value of 0.519.

Keywords: Radiotherapy, Breast Cancer, Treatment Planning System, Dose Distribution

I. INTRODUCTION

Breast cancer is a type of the most common cancer in women and can also happen in men. Factor risks include age, history family, and hormonal factors, such as consuming birth control pills and hormone therapy [1]. Symptoms of breast cancer include a lump in the breast, a change in the shape or size of the breast, and bleeding or discharge from the nipple. Diagnosis can be made through inspection physicals, mammography, and biopsies [2-3]. A number of choice therapy covers surgery, radiotherapy, chemotherapy, and hormonal therapy. Treatment is chosen based on the stage of cancer, tumor size, and the patient's health condition [4]. Usually, radiotherapy is chosen as a cancer treatment because this treatment can kill cancer cells and help prevent cancer recurrence after surgery [5]. Before the patient is irradiated, dose planning must be carried out. Planning is carried out in a treatment planning system

(TPS) with several available engineering options [6]. In this study, we chose two techniques, namely intensity-modulated radiotherapy (IMRT) and volumetric-modulated arc therapy (VMAT) techniques.

To determine the quality of the dose planning of these two techniques, a comparison of the heterogeneity index (HI) and conformity index (CI) parameters was carried out. The heterogeneity index in radiotherapy is used to measure the variation in radiation dose across the entire tumor volume, thus indicating how heterogeneous the dose received by the tumor is [7]. The greater the heterogeneity value, the more varied the dose received by the tumor. This can be problematic because it can prevent cells receiving very low doses from dying, thus allowing tumor growth. Meanwhile, the conformity index in radiotherapy is a measure that describes how well the radiation dose is applied to a target, taking into account how the form of the dose matches the shape of the target. The higher the conformity index, the better the radiation dose is applied to the target, which means that the radiation dose is more effective in killing cancer cells and minimizing the effect on healthy tissue. This is important because applying an ineffective dose can increase the risk of side effects and worsen the outcome of therapy [8]. In addition, CI can ensure that tumor cells receive the optimal radiation dose while minimizing damage to the surrounding normal tissue. Therefore, CI is commonly used as a measure of radiotherapy outcomes and to compare outcomes of various radiotherapy techniques [9].

II. METHODS AND MATERIAL

A. Selection of Patient and Initial Imaging

Ten consecutive patients with advanced breast cancer treated with radiotherapy were included in this study. The ten patients had stage T4 with N0 (5 patients) and N3 (5 patients). The mean age was 56.9 years (range 32-65). All patients were immobilized, simulated, and treated in a supine position. The breast image was scanned with a CT scanner (GE Discovery) with a slice thickness of 3.75 mm. After scanning, the patient's DICOM (Digital Imaging Communication in Medicine) image is imported into the PC with Monaco 5.11 Elekta software.

B. Treatment Planning

All patients underwent dose planning using the IMRT and VMAT techniques at TPS Monaco for further comparison of HI and CI at the target (PTV). The algorithm used in TPS Monaco is Monte Carlo. The specified dose is 50 Gy for PTV volume given in 25 fractions in one treatment dose of 2 Gy. Parameters for the coverage of received doses must meet D95% (dose 95%) to V95% (volume ≥95%) and a maximum dose of 107% [The ICRU Report 83].

C. Analysis Statistics Comparison of HI and CI of IMRT and VMAT Techniques

In statistical analysis, all HI and CI result from IMRT and VMAT irradiation techniques were compared to each other, then paired two-tailed t-tests were used. The results are considered statistically significant if the p-value <0.05

III.RESULTS AND DISCUSSION

The results in this study are presented quantitatively by calculating HI and CI obtained automatically from TPS Monaco on the IMRT and VMAT irradiation techniques. The HI and CI values can be seen in table 1. Based on table 1, the HI values were obtained for the IMRT technique of 1.081 and for the VMAT technique of 1.060 with the t-test ($p < 0.05$ considered statistically different) p-value = 0.018 which differed statistically significantly. This shows that HI scores using the VMAT technique show better homogeneity when compared to the IMRT technique. Meanwhile, the CI value for the IMRT technique was 0.519 while the VMAT technique was 0.641. The results of the t-test p-value = 0.263 showed no significant difference. This shows that the VMAT technique conforms more than the IMRT technique because it produces a greater CI value. Because VMAT is more conformable, this technique is expected to be able to minimize the absorbed dose to the organs at risk.

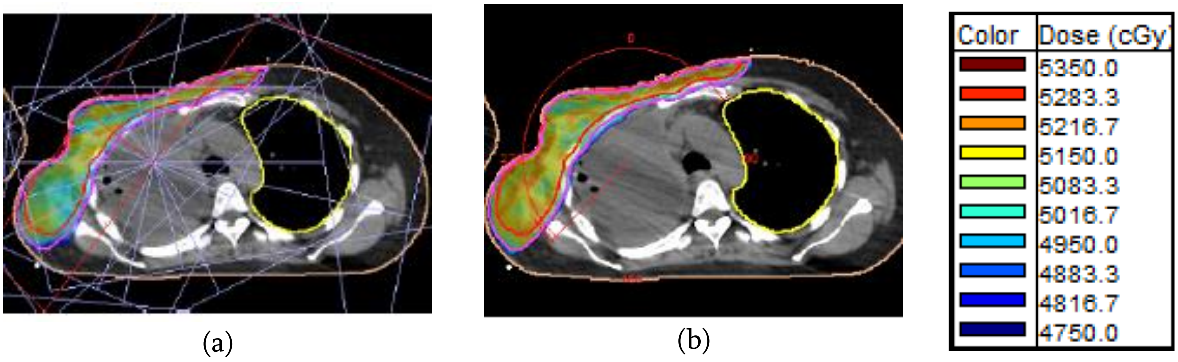
Dose homogeneity can also be observed based on the dose distribution map at V95% as shown in Figure 1. It can be seen that the distribution in the VMAT technique is more homogeneous and the range of doses is closer to the dose description. This is indicated by a more even yellow color in the VMAT technique. Meanwhile, in the IMRT technique, the blue-colored dose distribution is still visible. This shows that the range of doses is still far from the prescribed dose. Lastly, based on unit monitor comparison between the IMRT and VMAT techniques, both techniques show high MU values 3 – 4 times the described MU. This shows that both techniques have the possibility to cause secondary malignancy if not considered comprehensively.

IV. CONCLUSION

The results of the comparison between IMRT and VMAT show that VMAT is superior to IMRT in terms of homogeneity and conformity. This is consistent with the HI results on VMAT showing a mean of 1.060 while IMRT shows a mean of 1.081. In addition, the CI results at VMAT showed a mean of 0.641 while IMRT showed a CI value of 0.519.

TABLE I
PLANNING PARAMETERS OF DOSE DISTRIBUTION AT PTV/TARGET

	Mean		
	IMRT	**VMAT**	**p-values**
Heterogeneity Index	1.081	1.060	0.018
Conformity Index	0.519	0.641	0.263



(a) (b)

Figure 1. Dose distribution served in the form of gradation colors with (a) IMRT and (b) VMAT techniques

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