Journal of Integrated and Advanced Engineering (JIAE)
Vol. 3, No. 2, September 2023: 151-156
http://asasijournal.id/index.php/jiae
http://doi.org/10.51662/jiae.v3i2.109

Analysis of Geometry Verification of X, Y, Z Correction Values with Megavoltage Computed Tomography Using Lower Extremity Positioning System in Prostate Cancer

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Abstract
The immobilization tool is used to minimize the movement caused while doing irradiation, one of the immobilization tools is the Lower Extremity Positioning System (LEPS) which is used to minimize movement in the Pelvis area. This research was conducted at Dr. Cipto Mangunkusumo Central General Hospital. This research is analytics quantitative, that were used 15 samples with secondary data, which were selected based on inclusion and exclusion criteria. The secondary data will be analyzed namely the consistency between the Set-Up value (Couch Position before verification) and the Couch Position after verification (MVCT) value using Non-Parametric Wilcoxon statistical test, and evaluating the shifting values of X, Y and Z with tolerance standards from AAPM TG-148 which is 2 mm. The results obtained are based on statistical analysis of the Set-Up value with the MVCT results obtained that there is no significant difference, and based on the overall substance, the total that exceeds the tolerance of X coordinates is 92 times with a percentage of 68%, from Y coordinates that is 80 times with a percentage of 59%, from the Z coordinate which is 51 times with a percentage of 38% there is a shift that exceeds tolerance. The conclusion is that the results of MVCT verification still occur that exceed the tolerance standard so that LEPS is still not effective in preventing shifts that occur during radiation therapy.

Keywords:
LEPS;
Prostate Cancer;
TomoTherapy;
Verification of MVCT;

Article History:
Received: August 6, 2023
Revised: September 2, 2023
Accepted: September 3, 2023
Published: September 8, 2023

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INTRODUCTION

Prostate cancer is the most common cancer in men. According to data statistical from Global Cancer Observatory (GLOBOCAN) issued by the International Agent Cancer Registry (IARC) in 2018 Prostate cancer has 1,276,106 new cases and is ranked 3rd most worldwide and 358,989 deaths [1][2], and for Indonesia Prostate cancer in ranks 12th with 11,361 new cases and 5,007 causes of death [3]. Prostate cancer is more common in men over the age of 60 years [4]. Metabolic syndrome has been linked to an increased risk of prostate cancer, but there is not enough evidence to recommend lifestyle changes or a modified diet to reduce this risk. There are no approved drugs or food supplements for the prevention of prostate cancer [5][6].

The main examination in knowing prostate early-stage cancer is the examination of DRE (Digital Rectal Exam), Ultrasonography, Score Gleason and laboratory examination of PSA (Prostate Specific Antigen). Medical therapy can be done in 3 ways, namely surgery,

radiotherapy, and hormonal therapy [4, 6, 7]. The more development of technology, radiotherapy continues to develop rapidly with a variety of techniques including, 2D, 3DConformal Radiation Therapy (3DCRT), Intensity Modulated Radiotherapy (IMRT), Image-guided Radiation Therapy (IGRT), Volumetric Radiation Therapy (VMAT), and TomoTherapy in medical therapy for various cancers using X-rays. TomoTherapy is the development of radiotherapy technology using techniques IMRT that have higher accuracy, and a wider range of the therapeutic targets than LINAC. TomoTherapy is use scanning CT, in principle like CT-Scan which is used for cancer therapy.

TomoTherapy can provide radiation with the rotation direction gantry of 360^0 and has higher accuracy and more therapeutic planning in accordance with the actual shape of the tumor. So that it can provide the optimal dose to the target tumor and healthy tissue around the target can be protected from radiation given as in Organ at Risk (OAR) *Rectum* and Urinary bladder avoid excessive radiation [8][9]. The treatment planning Hi-ART TomoTherapy system uses a different set of factors from pinnacle to control dose administration. For treatment, the factor is 'tight' was applied are 0.25 and 0.30 only. The primary collimation jaw is set to a width of 2.45cm in the isocenter to determine the width of the fan beam. The modulation factor 2.0 is used for all plans [10][11].

Every time radiotherapy examination the first thing is always verification, the function is to avoid errors or inaccurate targets when irradiating [12]. Verification is divided into 2 are geometry verification and dosimetry verification. Geometry verification in the form of coordinates X (*Lateral*), Y (*Longitudinal*) and Z (*Vertical*), aims to obtain data on the amount of systematic and random errors that occur during the therapy process [13]. When treatment of radiation, it is important to use a fixation device because the fixation device directly affects the accuracy of the target and aims to prevent the undesired movement of the patient [14]. MVCT is a verification used in TomoTherapy. MVCT uses energy 3.5 MV with processes Scan such as CT scan which uses the principle of Fan Beam. The purpose of verification is using *MVCT* be able to minimize the error of Set-Up for each radiation therapy [15][16].

Based on the author's observations, radiation treatment in *prostate* cancer in the Department of Radiotherapy Dr. RSUPN Cipto Mangunkusumo is verified every day, the verification is carried out so that radiation therapy can be optimal and fixation tools are needed, because in the area there are many adjacent of critical organs. Therefore, at the RSCM use the fixation is *LEPS* (Lower Extremity Positioning System) to minimize the movement of patients in the area *Pelvis* [17] with a geometry shift tolerance limit of the American Association of Physicists in Medicine (*AAPM*) Commissioned Task Group 148 (*TG-148*) of 2 mm [18].

MATERIALS AND METHOD

This study aims to describe, analyze the consistency between the Set-Up value (Couch position before verification) with X, Y, and Z coordinate values of the MVCT (Couch position after verification) using LEPS. After that, to evaluate the results of the verification shift MVCT with tolerance limits. The study was conducted in the Department of Radiotherapy RSUPN Dr. Cipto Mangunkusumo on the March to April 2020. The study used 15 secondary samples which the result of verification Mega Voltage Computed Tomography (MVCT) in patients of prostate cancer with technique IMRT using the fixation is Lower Extremity Positioning System (LEPS). One of a LEPS kind is presented in Figure 1.

Figure 1. A LEPS

Criteria Inclusion include patients with cancer clinical prostate doing with radiation therapy TomoTherapy using verification MVCT has been done Planning in CT-Simulator and calculation in Treatment Planning System (TPS). Using LEPS fixation, for male without age restrictions. Criteria Exclusion are Patients suffering from cancers other than Prostate cancer such as Cervix cancer, Nasopharyngeal cancer, brain cancer and etc. Patients who use fixation tools other than LEPS such as pull fix and body fix (Blue Bag) as well as Patients who radiotherapy other than in TomoTherapy devices such as LINAC Variant, Platform, and Synergi-S. Data collection techniques through literature study, secondary data verification of MVCT, discussion of the causes of X, Y and Z point coordinates.

RESULTS AND DISCUSSION

In the implementation of radiotherapy with prostate cancer must be verified. Every time a verification is done, the Set-Up patient's must be considered so that a verification shift to a seminal tumor target may occur. In Set-Up this patient's there are X, Y and Z coordinates which serve as clues to the shift couch. The results of MVCT verification are the coordinates of X, Y and Z which refer to the X, Y and Z values of the position Set-Up patient's. The difference between the Couch position before and after the MVCT is used to evaluate that the therapy is carried out optimally or requires the addition of fixation devices to minimize patient movement. Based on references from the American Association of Physicists in Medicine (AAPM) Commissioned Task Group 148 (TG-148), the geometry shift tolerance limit obtained couch is 2 mm.

Table 1 shows the statistical test between Couch Position before (Set-Up) and Couch Position after MVCT using non-parametric Wilcoxon results obtained are all fractions (from fractions 2 to 10) significance or probability values (p)> 0.05, which means that statistically in the Couch position before MVCT and Couch position after MVCT there is no significant difference.

Table 1. Wilcoxon Statistical Test for Every Fraction in Coordinate X, Y, Z

Coordinate point	Fract 2	Fract 3	Fract 4	Fract 5	Fract 6	Fract 7	Fract 8	Fract 9	Fract 10
X (mm)	0.21	0.87	0.79	0.39	0.33	0.14	0.33	0.28	0.98
Y (mm)	0.67	0.67	0.30	0.21	0.33	0.82	0.53	0.33	0.27
Z (mm)	0.43	0.23	0.40	0.61	0.08	0.73	0.66	0.87	0.29

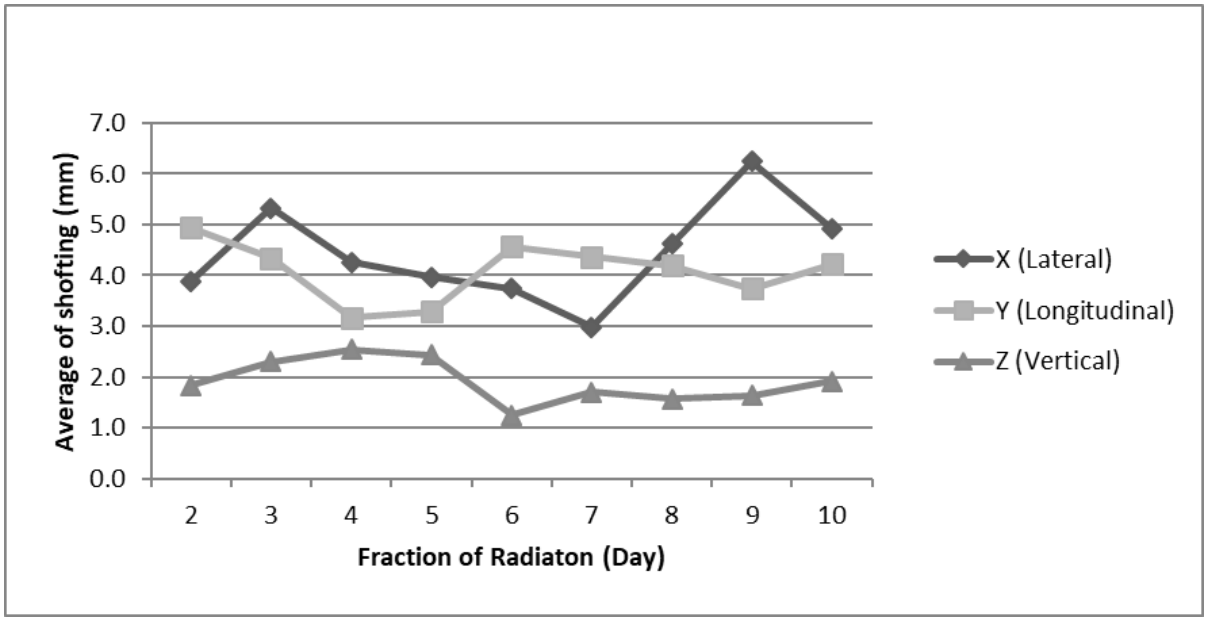

Figure 2. Shifting of MVCT for the coordinates X, Y and Z of fractions 2 to 10

At the Y coordinate point, all fractions experienced a shift that exceeded tolerance (2 mm), but what deceased tolerance was at the 4th fraction, with an average shift of (3.16 ± 2.60) mm, then the greatest shift value was at 2nd fraction with a mean shift of (4.90 ± 5.30) mm. At the Z coordinate point, fractions 3, 4, and 5 experienced a shift that exceeded tolerance (2 mm), but what was deemed tolerable was at the 3rd fraction with an average shift of (2.30 ± 1.90) mm then in the 2nd, 6th, 7th, 8th, 9th and 10th fractions are still below tolerance.

The results of average and standard deviation of the shift MVCT point coordinates X, Y and Z in fractions 2 to 10. In the table obtained at point X coordinate all factions shifted beyond the limit of tolerance (2 mm), but approaching tolerance is at the 7th fraction, with a mean shift of (2.9 ± 1.9) mm, then the greatest shift value is at the 9th fraction, with the average shifting (6.2 ± 3.6) mm.

Figure 2 shows a chart of the average shift of the X, Y and Z coordinates of fractions 2 to 10. Viewed from the average value of the X and Y coordinates, all fractions have a large shift value, and the coordinates X in the 9th fraction has the greatest shift value of 6.2 mm. At the Z coordinate point, there are 3 values that exceed tolerance, namely in the 3rd, 4th, and 5th fractions, but the shift value is still close to the tolerance limit.

Table 2 shows the frequency of verification shift results MVCT that exceed the limits of tolerance. The coordinate point that most exceeded the tolerance dose was the X coordinate point (Lateral) in the 9th fraction of 15 samples obtained 13 samples that exceeded the tolerance.

Table 2. Data on Frequency of Verification result exceeding tolerance limit based on AAPM TG-148 (2 mm)

Coordinate Point	Fraction									Total
	2	3	4	5	6	7	8	9	10	
X	10	11	9	11	10	10	9	13	9	92
Y	9	7	8	8	9	9	8	10	12	80
Z	5	8	9	9	2	4	6	4	4	51

The Y coordinate point (Longitudinal) in the 10th fraction obtained 12 samples that exceeded the tolerance. Also, Z (coordinates Vertical) at the 4th and 5th fractions have 9 samples that exceed tolerance. Overall, the coordinate points that shifted the least out of tolerance were the Z coordinate points in the 6th fraction, but only 2 samples exceeded tolerance.

The causes of this MVCT verification shift that occur are at the coordinates X, Y and Z can occur due to the movement of patients after Set-Up, positioning incorrect patient, loss of marks on the patient's body, index misalignment of padlock Genu or error of indexing lock bar and the pants that prop up the thig.

CONCLUSION

The results of statistical analysis using Wilcoxon's non-parametric test on the verification value of MVCT each fraction using LEPS showed no significant difference in the value of the Set-Up (Couch position before verification MVCT) with the value of the results MVCT (Couch position after verification MVCT). Based on the substance as a whole, the total that exceeds AAPM TG-148 (2 mm) tolerance of X coordinates is 92 times with a percentage of 68%, from Y coordinates 80 times with a percentage of 59%, from Z coordinates that is 51 times with a percentage of 38% of shifts exceed tolerance.

ACKNOWLEDGMENT

We would like to thank the Director of Politeknik Kesehatan Jakarta II, Ministry of Health for his contributions during the study. We are sincerely grateful to the Directors, Radiographers, Medical Physicist and staff of RSUPN Cipto Mangunkusumo Hospital Jakarta for their valuable contributions, facilities, assistance and constructive suggestions during our study. All of the interpretations/conclusions of this paper.

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