Analysis study of doses distribution in lung cancer using 3D Slicer

R Amaliya¹, St Aisyah¹, A P Hariyanto¹, F Jannah¹, A Sarasechan¹, Nasori¹, A Rubiyanto¹, M Haekal¹, Endarko¹, A Nainggolan²

¹Laboratory of Medical Physics and Biophysics Department of Physics, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo – Surabaya 60111, East Java, Indonesia
²Mochtar Riady Comprehensive Cancer Center Siloam Hospitals Semanggi – South Jakarta 12930, Indonesia

Corresponding author : endarko@physics.its.ac.id

Abstract. Lung cancer has decreased mortality rates each year that can treat with radiotherapy. The radiotherapy module is own by 3D Slicer that is open-source software. The purpose is to determine the distribution of doses on the dose-volume histogram (DVH) and the percentage of the suitability of the 3D Slicer simulation results with the Treatment Planning System (TPS) at MRCCC Siloam Hospital. The data used were three Computed Tomographic images of lung cancer patients obtained from the MRCCC Siloam Hospital. The parameters analyzed included volume, the dose of the target volume, and organ at risk (OAR). Analytical studies were carried out by comparing the target volume with The International Commission on Radiation Unit (ICRU) Report 83 and comparing the OAR regarding dose tolerance. The dose distribution of all patients from the simulated 3D slicer for OAR met the tolerance limit reference recommendations. The Planning Target Volume (PTV) of all patients also matched the evaluation recommended by the ICRU Report 83. The percentage value of the suitability between the 3D Slicer and TPS results for all patients was above 95%. It shows that 3D Slicer can use as a recommendation software for initial radiotherapy planning studies.

1. Introduction

In 2018, the World Health Organization (WHO) issued the facts that cancer ranks the second largest cause of mortality in the World. Lung cancer ranks first in the number of new cases and deaths from cancer, with 2,093,876 new cases and 1,761,007 deaths from lung cancer [1]. Lung cancer accounts for an accelerated decline in cancer deaths each year. From 2008 to 2013 recorded 3% for men and 2% for women. Then decreased to 5% in men and reached 4% in women during 2013-2017. The number of deaths in 2017 from lung cancer is still more extensive than the combined of cancer brain, colorectal, prostate, and breast [2].

Treatment procedures to treat cancer are chemotherapy, surgery, radiation therapy, drug therapy, and cell transplantation [3]. The standard treatment method for lung cancer is surgery. Surgery can lead to postoperative recurrences, such as distant metastases or locoregional recurrence, with a recurrence rate of 8% to 37%. The advantage of radiotherapy over other methods is that it can treat regional relapses with better regional response rates and increased survival [4]. Besides, radiotherapy can relieve symptoms of intrathoracic tumors [5]. Radiotherapy used the Linear Accelerator (Linac) is connected to the Treatment Planning System (TPS). TPS is a computational algorithm model to calculate the dose
distribution in a complex state-shaped an isodose curve during therapy planning [6]. TPS in the hospital usually uses commercial software with algorithms that have a high level of accuracy so that quality is guaranteed in the medical field [7], such as the Varian Eclipse with anisotropic analytical algorithm (AAA) [8].

One thing to consider in radiotherapy is radiation planning. The irradiation planning will affect the dose received by cancer cells and normal tissue or organs at risk. Radiotherapy planning lessons can use free, open-source software that radiation workers and students can use, for example, 3D Slicer. 3D Slicer is a free downloadable software for the segmentation, registration, and visualization of medical imaging data. The 3D Slicer has many modules that can use in the medical field, one of which is the radiotherapy module. Radiotherapy module exists external beam planning, Dose-Volume Histogram, DVH comparison, and dose evaluation. The results obtained from the 3D Slicer can be in the form of a Dose-Volume Histogram [9]. Optimization of planning from DVH data with adjust the number and angle, block formation, and the best planning to provide high coverage and minimize the dose for organs at risk (OAR) [10].

An experiment not regardless of error or uncertainty. Therefore, this study simulates the suitability of radiotherapy planning results between 3D Slicer software and TPS at MRCCC Siloam Hospital, South Jakarta. The analysis carried out on the dose distribution in the dose-volume histogram and the percentage of the suitability of the 3D Slicer simulation results with TPS. The homogeneity index calculation will also examine. In this study, the results were as expected to use as a preliminary study in radiotherapy planning.

2. Methods

2.1. Computation system
The devices used in this research process include hardware and software. The hardware specifications used in the simulation consist of an ASUS VivoBook S14 laptop with an Intel Core i3-8130U CPU 2.20 GHz and a memory capacity of 4 GB. Simulation using Microsoft Windows 10 Home Single Language Version 1809 and 3D Slicer 4.10.1 software.

2.2. Patient data
In this part, we used three lung cancer patient data, using the Intensity Modulated Radiation Therapy (IMRT) technique, and the photon energy of 6 MV. The treatment planning system of three image data did carry out in MRCCC Siloam Hospital, South Jakarta. The characteristics of each patient in this radiotherapy planning simulation are present in Table 1.

| Table 1. Patient characteristics |
|----------------------------------|
| Characteristics | Patient 1 | Patient 2 | Patient 3 |
| Gender           | Male      | Male      | Female    |
| Total Dose       | 40 Gy     | 40 Gy     | 54 Gy     |
| Fraction         | 20        | 20        | 30        |
| Cancer location  | Right     | Left      | Right     |

2.3. Data processing
The simulation went through the extensions SlicerRT Radiotherapy module in 3D Slicer to data analysis. The first is the accumulated dose from the DICOM data carried out by loading the DICOM data into the 3D Slicer. Furthermore, calculate the Dose-Volume Histogram and see the dose distribution using the DVH. The calculated data is the accumulated dose from the first step and the RTDOSE Eclipse Doses IMRT.
2.4. Dose distribution analysis
In this part, a dose distribution analysis went through by observing the DVH generated from the 3D Slicer simulation, namely volume, minimum dose, maximum dose, mean dose of the target volume, and each organ at risk. Moreover, we observed the percentage of the volume at a dose of 20 Gy ($V_{20}$) and 30 Gy ($V_{30}$) and dose at 99% volume ($D_{99}$).

2.5. Comparison of DVH
The analysis results in DVH from 3D Slicer simulation will compare with the TPS results at the MRCCC Siloam Hospital, South Jakarta. Parameters such as volume, mean dose, and dose to the target volume of 99% volume and OAR compared to each patient. The deviation or difference in the results of the 3D Slicer simulation with the TPS of the MRCCC Siloam Hospital, South Jakarta, will be calculated using relative errors to find out how far the difference [11] by using the Equation (1):

$$\text{Relative error} = \frac{|\Delta x|}{x} \times 100\%$$ (1)

Where $|\Delta x|$ is the absolute error means the difference between the results of the 3D Slicer simulation and the TPS. $x$ is the measurement result, namely the TPS result. The relative error can indicate the quality of measurement results. A smaller relative error value means that the measurement result is accurate [11].

2.6. Comparison by reference
According to the International Commission on Radiation Units and Measurements (ICRU) Report 83 [12], the dose received by the PTV was analyzed. Then volume percentage parameters at doses of 20 Gy ($V_{20}$) and 30 Gy ($V_{30}$) were compared with the reference tolerance limits for each organ at risk for all patients. Reference tolerance limits for each organ at risk are obtained from the literature, present in Table 2 [13-14]. Dose homogeneity is the uniformity of dose distribution absorbed by the target volume. Homogeneity calculations usually use the homogeneity index (HI). HI calculation refers to Equation (2):

$$HI = \frac{D_{2\%} - D_{98\%}}{D_{50\%}}$$ (2)

HI is the homogeneity index, $D_{2\%}$ is the high absorption dose area, $D_{98\%}$ is the low absorption dose area, and $D_{50\%}$ is the mean absorption dose area. The dose distribution implies uniform when HI is zero [12].

| Structure      | Emami, 1991 [13] | Barrett et al., 2009 [14] |
|----------------|-----------------|---------------------------|
| Heart          | $V_{25} < 10\%$ | $V_{40} < 30\%$           |
|                | $V_{30} < 46\%$ | $D_{\text{max}} < 60\text{ Gy}$ |
|                | $D_{\text{mean}} < 26\text{ Gy}$ |                       |
| Spinal cord    | $D_{\text{max}} = 50\text{ Gy}$ | $D_{\text{max}} < 46\text{ Gy}$ |
| Lung           | $V_{20} < 31\%$ | $V_{30} < 10-15\%$       |
|                | $D_{\text{mean}} < 13\text{ Gy}$ |                       |

3. Results and discussion

3.1. Comparison of DVH
Figure 1 shows the simulated data of DVH from all patients resulted from both 3D Slicer and TPS with the PTV structure in DVH is marked with a cross. It can be seen that both graphs have a similar pattern. It indicates that both have similar results. For further analysis, the two graphs were then compared for
volume values, mean dose, and $D_{99}$ as summarized in Table 3. It can be analyzed from Table 3 that the mean dose of 3D Slicer simulation compared to TPS results from patient 1 was lower 0.45 Gy with a relative error of 1.08%, and PTV coverage ($D_{99}$) decreased with a ratio of 38.6% versus 37.01%, respectively.

Meanwhile, in-patient 2, the mean dose for simulated 3D Slicer was 0.12 Gy lower than TPS with a relative error of 0.29%. $D_{99}$ of PTV coverage also decreased to 36.1%. Likewise, with patient 3, the mean dose was lower at 0.15 Gy with a relative error of 0.28%, and the PTV dose coverage at 99% volume ($D_{99}$) decreased by a ratio of 49.28% versus 51.3% for TPS.
Table 3. Comparison data of the target volume for 3D Slicer and TPS

| Patient | Structure                  | 3D Slicer | TPS  | Relative error (%) |
|---------|----------------------------|-----------|------|---------------------|
| 1       | PTV 40Gy Volume (cc)       | 31.90     | 30.90| 3.25                |
|         | PTV 40Gy $D_{\text{mean}}$ (Gy) | 41.46     | 41.91| 1.08                |
|         | PTV 40Gy $D_{99}$ (Gy)     | 37.01     | 38.60| 4.11                |
| 2       | PTV 40Gy Volume (cc)       | 62.57     | 61.20| 2.24                |
|         | PTV 40Gy $D_{\text{mean}}$ (Gy) | 40.65     | 40.77| 0.29                |
|         | PTV 40Gy $D_{99}$ (Gy)     | 36.10     | 37.50| 3.72                |
| 3       | PTV 54Gy Volume (cc)       | 43.36     | 42.20| 2.75                |
|         | PTV 54Gy $D_{\text{mean}}$ (Gy) | 53.85 | 54.00| 0.28                |
|         | PTV 54Gy $D_{99}$ (Gy)     | 49.28     | 51.30| 3.93                |

3.1.1. Patient 1. DVH analysis of OAR for patient 1 was referred to Table 4. It can be seen that the mean dose values contained in the structure of the right lung (Lung_R) of 4.47 Gy (3D Slicer) and 4.49 Gy (TPS). The smallest dose received by the heart was at 0.17 Gy (3D Slicer) and 0.17 Gy (TPS). The mean dose of 3D Slicer simulation results is decreased compared to the hospital TPS results. The largest decrease in the mean dose locates in the spinal canal structure, with a relative error value of 1.47%. Meanwhile, the smallest reduction from the mean dose founds in the heart structure with a relative error value of 0.06%.

Table 4. The organ at risk for patient 1

| Structure                  | 3D Slicer | TPS  | Relative error (%) |
|----------------------------|-----------|------|---------------------|
| Heart Volume (cc)          | 312.85    | 309.60| 1.05                |
| Heart $D_{\text{mean}}$ (Gy) | 0.17     | 0.17  | 0.06                |
| Spinal Canal Volume (cc)   | 76.78     | 77.60| 1.06                |
| Spinal Canal $D_{\text{mean}}$ (Gy) | 0.73  | 0.74  | 1.47                |
Total Lung Volume (cc) 2471.47 2480.30 0.36
Total Lung $D_{\text{mean}}$ (Gy) 2.66 2.67 0.53
Lung_R Volume (cc) 1353.93 1358.50 0.34
Lung_R $D_{\text{mean}}$ (Gy) 4.47 4.49 0.54
Lung_L Volume (cc) 1117.53 1121.70 0.37
Lung_L $D_{\text{mean}}$ (Gy) 0.47 0.47 0.56

3.1.2. Patient 2. Table 5 shows the analysis of DVH at OAR for patient 2. It can be analyzed that the largest dose received by the OAR of the left lung with $D_{\text{mean}}$ was at 10.31 Gy (3D Slicer) and 10.32 Gy (TPS). The smallest mean dose received by the OAR of the spinal cord, $D_{\text{mean}}$ was at 1.19 Gy (3D Slicer) and 1.19 Gy (TPS). Differences in the mean value of dose in patients 2, most located in the heart (relative error = 1.43%). Meanwhile, the smallest error value is found by the organ at risk of the left lung, which is 0.17%.

| Structure              | 3D Slicer | TPS   | Relative error (%) |
|------------------------|-----------|-------|--------------------|
| Heart Volume (cc)      | 571.35    | 570.00| 0.24               |
| Heart $D_{\text{mean}}$ (Gy) | 3.44      | 3.39  | 1.43               |
| Spinal Cord Volume (cc)| 41.94     | 42.60 | 1.56               |
| Spinal Cord $D_{\text{mean}}$ (Gy) | 1.19      | 1.19  | 0.17               |
| Lung RT Volume (cc)    | 1119.33   | 1126.20| 0.61              |
| Lung RT $D_{\text{mean}}$ (Gy) | 2.56      | 2.56  | 0.19               |
| Lung LT Volume (cc)    | 819.64    | 824.50| 0.59               |
| Lung LT $D_{\text{mean}}$ (Gy) | 10.31     | 10.32 | 0.17               |

3.1.3. Patient 3. Table 6 shows the received dose at the OAR for patient 3. It can be seen that the most received dose to the OAR that occurred at the right lung with $D_{\text{mean}}$ was at 11.84 Gy (3D Slicer) and 11.87 Gy (TPS). The OAR that received the smallest dose was at the left lung with a $D_{\text{mean}}$ of 2.05 Gy (3D Slicer) and 2.05 Gy (TPS). The difference in the percentage means dose between the 3D Slicer simulation results and the TPS of Hospital received by the OAR has the higher value in the right lung structure (relative error = 0.28%) whereas the smallest value on the heart structure (relative error = 0.08%).

| Structure              | 3D Slicer | TPS   | Relative error (%) |
|------------------------|-----------|-------|--------------------|
| Heart Volume (cc)      | 502.64    | 499.30| 0.67               |
| Heart $D_{\text{mean}}$ (Gy) | 7.19      | 7.19  | 0.08               |
| Spinal Cord Volume (cc)| 35.66     | 35.20 | 1.30               |
| Spinal Cord $D_{\text{mean}}$ (Gy) | 2.83      | 2.84  | 0.25               |
| Total Lung Volume (cc) | 1698.88   | 1703.30| 0.26              |
| Total Lung $D_{\text{mean}}$ (Gy) | 7.75      | 7.77  | 0.21               |
| Lung RT Volume (cc)    | 989.58    | 991.10| 0.15               |
| Lung RT $D_{\text{mean}}$ (Gy) | 11.84     | 11.87 | 0.28               |
3.2. **Comparison of DVH 3D Slicer with reference**

3.2.1. **Lung dose analysis.** The lung is an organ that serves as the exchange of oxygen and carbon dioxide. The lungs are located in the upper chest cavity. In lung cancer, the cancer is located in the lung area, either the right or left lung. When radiation is done, it will hit the lungs and reduce the lung's performance. Therefore, the lung can be regarded as an organ at risk and raises the limits of tolerance. Lung structure analysis was carried out by comparing values of $V_{20}$, $V_{30}$, and the mean dose in each patient, as summarized in Table 7. The values were compared with the pulmonary structure tolerance limit values based on several references [13-14]. For patient 1, the percentage volume at a dose of 20 Gy ($V_{20}$) for the left lung structure was 0%, implying that the left lung received a dose of less than 20 Gy. Meanwhile, the $V_{20}$ value of the right and left lung structures for patients 2 and 3, and the right lung for patient 1, still met the tolerance limit. Likewise, the total lung structure, $V_{20}$ values of patients 1 and 3, also still meet the reference tolerance limit. In the right lung of patient 2, the left lung of patients 1 and 3, the volume at a dose of 30 Gy was 0%, meaning that these structures received doses of less than 30 Gy. The value of $V_{30}$ for the structure of the right lung in patients 1 and 3, also the left lung structure for patient 2 still meet the tolerance limits of the reference [13-14]. Besides, for the entire lung structure of patients 1 and 3, the $V_{30}$ value was still below the tolerance limit. The mean doses of right-left and total lung structures for patients 1, 2, and 3 were still below the tolerance limits recommended by the reference [13-14].

| Lung structure | Patient 1 | Patient 2 | Patient 3 |
|----------------|-----------|-----------|-----------|
| RT $V_{20}$ (%) | 8.15      | 0.09      | 24.90     |
| RT $V_{30}$ (%) | 4.65      | 0.00      | 11.20     |
| RT $D_{mean}$ (Gy) | 4.47  | 2.56      | 11.84     |
| LT $V_{20}$ (%) | 0.00      | 14.51     | 0.01      |
| LT $V_{30}$ (%) | 0.00      | 5.33      | 0.00      |
| LT $D_{mean}$ (Gy) | 0.47  | 10.31     | 2.05      |
| Total $V_{20}$ (%) | 4.47 | -        | 14.51     |
| Total $V_{30}$ (%) | 2.55 | -        | 6.52      |
| Total $D_{mean}$ (Gy) | 2.66 | -        | 7.75      |

3.2.2. **Heart dose analysis.** The heart is an organ that pumps blood throughout the body and carries nutrients and oxygen needed by all organs in the body. The location of the heart is between the lungs. Thus, the heart is significantly at risk of exposure to radiation on lung cancer treatment and can reduce the heart’s work function. Therefore, the heart is an organ at risk, and tolerance limits are imposed. The heart structure analysis was carried out by comparing values of $V_{30}$, mean dose, and maximum dose in each patient, as in Table 8. These values are then compared with the tolerance values for heart structures based on several references [13-14]. The patient 1, the percentage volume at 30 Gy ($V_{30}$) was 0%, implying that no heart volume received a dose of 30 Gy. The dose received was less than 30 Gy. Patient 2, $V_{30}$ was 0.54%, which means that about 0.54% of the heart volume of the patient 2 simulated 3D Slicer received a dose of 30 Gy. Meanwhile, patient 3 received a dose of 30 Gy ($V_{30}$), but it was still below the tolerance limit. The mean doses ($D_{mean}$) and maximum dose ($D_{max}$) received by patients 1, 2, and 3 were also below the tolerance limit. The values of $V_{30}$, $D_{mean}$, and $D_{max}$ for the cardiac structure of
patients 1, 2, and 3 are still below the tolerance threshold or dose limitation recommended by the reference [13-14].

### Table 8. The heart structure dose value simulated from 3D Slicer

| Heart Structure | Patient 1 | Patient 2 | Patient 3 |
|-----------------|-----------|-----------|-----------|
| $V_{30}$ (%)    | 0.00      | 0.54      | 6.99      |
| $D_{\text{mean}}$ (Gy) | 0.17      | 3.44      | 7.19      |
| $D_{\text{max}}$ (Gy) | 0.75      | 41.26     | 54.05     |

3.2.3. **Spinal cord dose analysis.** The spinal cord is a nerve extension of the central nervous system located in the brain that functions as the transmission of stimuli and controls reflex movements. The spinal cord is protected by the spine located behind the lungs. Hence, the spinal cord is at risk of radiation exposure to lung cancer treatment. Therefore, the spinal cord is an organ at risk, and tolerance limits are required. The analysis was carried out by comparing the maximum dose value ($D_{\text{max}}$) in each patient, as in Table 9. These values are then compared with the tolerance limit value for spinal cord structures based on several references [13-14]. The spinal canal structure represented patient 1, the structure of the spinal cord represented patient 2, and patient 3 for volume percentage at the dose of 30 Gy ($V_{30}$) was only own in patient 3, namely 3.3% of the spinal cord volume, meaning that only patient 3 received the 20 Gy dose. Patients 1, 2, and 3 for volume percentage at the 30 Gy ($V_{30}$) dose were 0%, meaning that all three patients received doses below 30 Gy. The maximum doses ($D_{\text{max}}$) received by patients 1, 2, and 3 were still below the tolerance limits recommended by the reference [13-14].

### Table 9. The dose value of the spinal cord structure simulation results from 3D Slicer

| Structure of spinal cord/ spinal canal | Patient 1 | Patient 2 | Patient 3 |
|---------------------------------------|-----------|-----------|-----------|
| $V_{20}$ (%)                           | 0.00      | 0.00      | 3.30      |
| $V_{30}$ (%)                           | 0.00      | 0.00      | 0.00      |
| $D_{\text{mean}}$ (Gy)                 | 0.73      | 1.19      | 2.83      |
| $D_{\text{max}}$ (Gy)                  | 8.78      | 9.12      | 27.32     |

In ICRU 83, the maximum dose ($D_{\text{max}}$) absorbed by PTV determine using the $D_{2\%}$ dose volume. The minimum dose ($D_{\text{min}}$) absorbed by PTV was determined using the $D_{98\%}$ dose volume. The mean dose ($D_{\text{mean}}$) absorbed by PTV was determined using the $D_{50\%}$ of dose volume. Therefore, the maximum dose, minimum dose, and mean dose of PTV from the 3D Slicer simulation results were evaluated using $D_{2\%}$, $D_{98\%}$, and $D_{50\%}$ according to the recommendations of the ICRU Report 83 as summarized in Table 10. Table 10 also shows the value of the homogeneity index (HI) obtained by patients 1, 2, and 3; 0.13, 0.12, and 0.09, respectively.

### Table 10. Comparison of PTV from 3D Slicer simulation results

| Structure of PTV | Patient 1 | Patient 2 | Patient 3 |
|-----------------|-----------|-----------|-----------|
| $D_{2\%}$ (Gy)  | 43.10     | 42.06     | 55.06     |
| $D_{50\%}$ (Gy) | 41.82     | 40.98     | 54.12     |
| $D_{98\%}$ (Gy) | 37.72     | 37.25     | 50.21     |
| HI              | 0.13      | 0.12      | 0.09      |

3.3. **Analysis of target volume and OAR**

From the analysis, we found an increase in the target volume coverage without increasing the target volume structure’s dose in the 3D Slicer simulation results. The mean dose received by PTV and the
dose coverage at 99% volume ($D_{99}$) was lower than that of TPS. For a non-conformity, the relative error values obtained for patients 2 and 3 were almost the same, except for patient 1, who had a high non-conformity value.

From Table 3, the results obtained from the 3D Slicer simulation for the target volume are still acceptable. It is proven by taking the largest relative error of all PTV parameters for each patient and calculating the percentage value of suitability. Of all the PTV parameters of patient 1, the relative error value was 4.11%. The lowest percentage suitability of the relative error values for the PTV parameter of patient 1 is

$$\text{Suitability PTV patient 1} = 100\% - 4.11\% = 95.89\% \quad (3)$$

The lowest suitability for the PTV parameter for patient 2 was 96.28%. The lowest suitability for the PTV parameter of patient 3 was 96.07%. It indicated that for the PTV value of the 3D Slicer simulation results, the suitability percentage is above 95%.

The parameters analyzed on the PTV are the same as the Hospital’s Treatment Planning System (TPS). We use IMRT techniques, so $D_{max}$ was determined using a $D_{2\%}$ dose volume, $D_{mean}$ using $D_{98\%}$ dose volume, and $D_{mean}$ using $D_{50\%}$ dose volume. The IMRT technique adjusts the number and area of the field, the direction of irradiation, and the provision of different radiation intensities. Besides, optimization examines that the resulting radiation intensity is inhomogeneous so that it is following the desired dose distribution for each target volume and normal tissue. It means that the IMRT technique prioritizes avoidance of normal tissue (organs at risk) rather than homogeneity of doses received by PTV, corresponding to the ICRU Report 83 [12]. Based on Table 10, the obtained HI values are close to zero, implying that all patients have good target volume homogeneity [12].

The parameters analyzed for organs at risk were the same as the TPS in the hospital. The volume of organs at risk shows a difference between the simulation results and the TPS results. When using the 3D Slicer, the volume values increase in structures to get a low dose, such as a heart. While the volume decrease in the structures that receive high doses, such as lungs. Besides, the mean dose received by OAR also decreased. However, this reduction in mean dose did not apply to the cardiac structures of patients 2 and 3.

Based on the Tables 4, 5, and 6. The results obtained from the 3D Slicer simulation for organs at risk are still acceptable. The lowest value of suitability for each patient can be found by using the highest relative error value of all OAR parameters for each patient. In Table 4, the structure of the spinal canal, the mean dose of patient 1 has the largest relative error among all structures, namely 1.47%, then the suitability value is

$$\text{Suitability OAR patient 1} = 100\% - 1.47\% = 98.53\% \quad (4)$$

The suitability of patient 2 was 98.44%; patient 3 was 98.7%. From this value, it can recognize that the suitability for organs at risk of all patients is above 98%.

The discrepancy between the 3D Slicer with TPS MRCCC Siloam Hospital in South Jakarta can occur because we use the 3D Slicer software with SlicerRT extension. Meanwhile, the MRCCC Siloam Hospital used Eclipse software with the Anisotropic Analytical Algorithm (AAA). It is a convolution or superposition method used to find the dose distribution in Eclipse treatment planning. Of the few studies that have been conducted, the AAA algorithm has proven consistent and more accurate in terms of dose distribution and measurement in heterogeneous media [8]. So that makes the AAA algorithm one of the algorithms with a high level of accuracy. Therefore, the 3D Slicer simulation results have a different value from the TPS results at MRCCC Siloam Hospital, South Jakarta.

The comparison results from the different cancer cases should be close. That is because the software used during the comparison simulation was the same. Factors that influence the differences are size, location, and radiotherapy planning of the tumor. Furthermore, differences in simulation during dose measurement using 3D Slicer and TPS can also affect. Therefore, the comparison of 3D Slicer with TPS in other cancer cases needs investigating further. There have not previously been similar studies comparing 3D Slicer and TPS, except in our laboratory. Therefore, this study tries to evaluate the
simulation results of 3D Slicer with TPS in the same case, namely lung cancer. Then compare them with existing standards. Following the title of this study, analysis study of doses distribution in lung cancer using 3D Slicer. It can provide an overview of the potential of 3D Slicer in radiotherapy planning learning, especially in the case of lung cancer. So that researchers can use 3D Slicer as initial learning in radiotherapy planning.

4. Conclusion
In this study, it can be concluded that the results of the simulation of 3D Slicer can be accepted and used as a reference for a preliminary study of radiotherapy planning. The distribution of doses in the dose-volume histograms was simulated by 3D Slicer for organs at risk of patients 1, 2, and 3 satisfy the tolerance limits recommended by the standard for radiotherapy planning. Meanwhile, PTV patients 1, 2, and 3 have met the evaluation requirements recommended by the ICRU Report 83. The percentage value of the suitability of the 3D Slicer simulation results, when compared to the TPS at the MRCCC Siloam Hospital for all structures, exceeds 95%.

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