Evaluation of doses distribution in breast cancer mastectomy using SlicerRT

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

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, Jakarta

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

Abstract. Treatment planning aimed to provide the maximum dose to target tumor and minimize doses received by healthy tissue. Dose-volume histograms contain essential information about the dose distribution that radiation oncologists use in considering treatment planning. In breast cancer mastectomy, the thickness of the thorax wall has decreased because of surgery. Therefore it is necessary to analyze the dose received by healthy tissue around the tumor. This study analyzes the doses distribution in breast cancer mastectomy using SlicerRT and compares it with treatment planning from the hospital. The study used three data patients from MRCCC Siloam Hospitals Jakarta. The simulation results were analyzed based on the International Commission on Radiation Units and Measurements Report’s 83 for target tumor and tolerance limits of healthy tissue according to limitations from various references. Although the target tumor’s homogeneity does not qualify, the healthy tissue around the tumor is still within tolerance. It is not a problem in intensity-modulated radiation therapy if avoidance of healthy tissue is more important than homogeneity. For the comparison result, the percentage acceptance of SlicerRT simulation is quite good, above 90%.

1. Introduction
Cancer is the second leading cause of death globally. According to the Global Cancer Observatory data from World Health Organization (WHO), most cancer cases in Indonesia are breast cancer, with 58256 cases or 16.7% of the total cancer cases in 2018. The Ministry of Health (Kemenkes) explained that as of January 31, 2019, the breast cancer rate in Indonesia had reached 42.1 people per 100000 population. The average death rate from this cancer was 23.4 people per 100000 population [1,2].

Treatment options include surgery, cancer medicines, and radiotherapy, combination. Alternative treatments that can be done for breast cancer are mastectomy surgery or breast removal surgery. However, microscopic residuals after surgery can create new cancer. According to research conducted by the Early Breast Cancer Trialist Collaborative Group (EBCTCG) in 2014, radiotherapy after a mastectomy is one of the steps in the effort to eradicate these microscopic residual diseases [3].

The radiotherapy plan’s evaluation is carried out using a radiation treatment planning system (TPS) before radiation is applied to the patient. The planning target volume (PTV) is defined to select appropriate beam arrangements, considering the following effect of all possible variations to ensure that the prescribed dose is absorbed in the clinical target volume (CTV). An organ at risk (OAR) is an organ whose sensitivity to radiation is such that the dose received from a treatment plan may be higher
compared with its tolerance so that the requiring a change in the beam arrangement or a change in the dose [4]. In general, hospitals use software such as Eclipse to assist exposure planning. The high case of cancer makes the tool limited to be used as a study and only focus on patient treatment in hospitals. Therefore, one solution is simulation-based research using software; in this study, we used the open-source 3D Slicer software. 3D Slicer is open-source software that contains information on the analysis and visualization of biomedical images. 3D Slicer is generally used for research and application development in medical diagnosis and therapy [5]. In addition to segmentation, registration, and rendering as elementary data processing, there is some module extension on 3D Slicer such as SlicerRT. SlicerRT can be used to evaluate radiotherapy dose distribution and modify it. The modules in the SlicerRT include the dose-volume histogram (DVH) to calculate and display the isodose curve of the desired dose volume and structure [6].

In the case of breast cancer mastectomy, radiation therapy is needed to reduce tumor residue. In this case, the thickness of the thorax wall has decreased due to surgery. Therefore it is necessary to analyze the dose received by the healthy tissue around the tumor in order not to cause a harmful effect. In the present study, we analyzed the dose distribution in breast cancer mastectomy using SlicerRT and then compared with the simulation results on TPS from the software in the hospital. The homogeneity index of dose uniformity is also investigated.

2. Methods

2.1. Patient data
The study was conducted using three data of patient breast cancer mastectomy from MRCCC Siloam Hospitals Jakarta. The data criteria required were mastectomy breast cancer patients with a total dose of 50 Gy in 25 fractions. In this study, three patient data were used as comparisons when analyzing the simulation results. Furthermore, the patients were referred to as Patient 1, Patient 2, and Patient 3. All patient data were determined and analyzed by medical physicists using the TPS software in the hospital, which will then be compared with 3D Slicer with SlicerRT extension.

2.2. Calculation of homogeneity index
Dose homogeneity characterizes the uniform distribution of the absorbed dose in the target volume, which indicates the extent to which high dose regions correspond to the target volume, is usually on planning target volume (PTV). Homogeneity index (HI) could commonly use for indicating the presence both over and underdose in the target volume. The greater of uniformity can reach if the value of HI is approaching zero. The definition of HI is the normalization of the maximum absorption dose minus the stated minimum absorption dose, as referred to in Equation 1. For breast cancer radiotherapy, dose uniformity is better obtained when using the Intensity-Modulated Radiation Therapy (IMRT) technique rather than using conventional radiotherapy. The IMRT technique can adjust a small area for high or low dose in the target volume if healthy tissue takes precedence overdose uniformity in PTV[7].

\[
HI = \frac{D_{2\%} - D_{98\%}}{D_{50\%}}
\]  

(1)

2.3. Data analyzing
The data analysis performed was the analysis of the dose distribution on PTV and OAR. Dose distribution analysis was performed by looking at the resulting DVH with the simulation results of 3D Slicer. From the DVH, we know the value of maximum dose, minimum dose, average dose, and \( V_{\text{dose}} \) and \( D_{\text{volume}} \). The evaluation of PTV based on the International Commission on Radiation Units and Measurements (ICRU) report 83 on IMRT, where the maximum dose was represented by the dose at 2% target volume (\( D_{2\%} \)), the minimum dose was represented by the dose at 98% target volume (\( D_{98\%} \)), and the average dose was represented by the dose at 50% target volume. (\( D_{50\%} \)) [7]. For the evaluation
of OAR, $V_{dose}$ and $D_{volume}$. 3D Slicer simulation results compared with tolerance limits. Reference to the OAR tolerance limits taken from several sources shown in Table 1.

**Table 1.** Healthy tissue tolerance for lungs, spinal cord, and heart from several references.

| Structure  | Reference 1 [8] | Reference 2 [9] | Reference 3 [10] |
|------------|----------------|----------------|------------------|
| Lung       | $V_{20} < 30\%$ | $V_{20} < 40\%$ | $V_{20} < 25 \%$ |
|            | $V_{30} < 20\%$ | $D_{mean} < 13 \text{ Gy}$ | $V_{30} < 10-15 \%$ |
|            | $D_{mean} < 15 \text{ Gy}$ | $D_{mean} < 10 \text{ Gy}$ |                   |
| Spinal Cord| $D_{max} < 45 \text{ Gy}$ | $D_{max} = 45 \text{ Gy}$ | $D_{max} < 46 \text{ Gy}$ |
| Heart      | $V_{20} < 10\%$ | $V_{20} < 10\%$ | $V_{20} < 50\%$ |
|            | $V_{30} < 5\%$ | $V_{30} < 46\%$ | $V_{30} < 10-45\%$ |
|            | $D_{mean} < 8 \text{ Gy}$ | $D_{mean} < 26 \text{ Gy}$ | $D_{mean} < 60 \text{ Gy}$ |

2.4. **Comparing data from simulation**

The analysis was carried out by comparing the DVH simulation results of 3D Slicer and TPS software in the hospital. The parameters compared include the maximum dose, minimum dose, and average dose on PTV and some of the organs at risks such as lungs, spinal cord, and heart for each patient. In this case, the dose distribution generated from the TPS is the reference data, while the dose distribution from the 3D Slicer as the experimental data. We need to define the acceptable deviation tolerance from a known standard. In radiotherapy, dose evaluation can be done by calculating the deviation of the result. The deviation is the difference between the calculated or measured value and the expected value obtained from some other method and considered a reference. Determination of the percentage deviation using Equation 2 that recommended by the International Atomic Energy Agency (IAEA), technical reports series (TRS) number 430 [11]:

$$\delta = 100 \times \left| \frac{D_{calc} - D_{meas}}{D_{meas}} \right|$$

where $\delta$ is the deviation in percent, $D_{calc}$ is the calculated or simulated dose and $D_{meas}$ is the reference dose. Equation 2 in measurement is also referred to as relative error; it states how much the absolute error is when compared to the actual value. The relative error is shown as a percentage. The higher deviation value it means the percentage of acceptance is getting smaller [12].

3. **Results and discussion**

Analysis of the simulation results was carried out on the PTV and OAR structures, which included the right lung, left lung, spinal cord, and heart in each patient.

3.1. **3D Slicer simulation analysis**

The graphic of DVH shows the relationship between the dose and volume fraction of each structure generated from the simulation using 3D Slicer is visually be similar to the simulation result from TPS for each patient, as shown in Figure 1, 2 and 3. For PTV tends to get the maximum dose in all its volume represented by the $x$ sign, and for OAR get the minimum dose represented by others line.
Figure 1. DVH results from 3D Slicer simulation (a) and TPS simulation (b) from Patients 1.
Figure 2. DVH results from 3D Slicer simulation (a) and TPS simulation (b) from Patients 2.

Figure 3. DVH results from 3D Slicer simulation (a) and TPS simulation (b) from Patients 3.
3.2. PTV and OAR analysis
Radiation protection has three general principles that need to be considered. There are optimization, limitation, and justification. In terms of medical exposure, optimization is to protect patients. The optimized dose of treatment is kept as low as reasonably achievable (ALARA). The limitation principle is to provide clear boundaries for this subjective procedure and also prevent the effect of radiation on individuals based on the recommended dose limit tolerance. The justification must generate benefits for all involved, including the patients and the radiation workers [13].

In the radiotherapy, we can use the three general principles to achieve the goals of radiotherapy. The dose of the PTV is related to the optimization principle, where the dose on cancer targets must be optimized. Using the IMRT, we can calculate the level of uniformity of the dose distribution on PTV according to ICRU report 83. Previously in ICRU report 50 and 62 recommended that the dose value in PTV is between 95% to 107% of the total dose prescribed. However, with IMRT, as described in the ICRU report 83, this limitation is unnecessary if avoidance of healthy tissue is more important than target dose homogeneity.

The limitation principle refers to the OAR, where the dose must be as minimum as possible. In addition to showing the maximum dose, the minimum dose, and the average dose, DVH also can be used to determine the percentage of volume receiving doses less or exceed the required tolerance. It is done for dose analysis on the OAR so that it can be a consideration for irradiation. After evaluating the PTV and OAR, the best radiation plan that can be done will be determined. This is related to the principle of justification. The ICRU is the ideal recommendation oncological justification. However, in clinical practice, the radiation oncologist's justification is not only based on the ICRU. Radiation oncologists have their own considerations in determining the area of PTV with various considerations, including the hot spot, so that it is not too high or the dose received is less than tolerance. So if the area of the tumor has covered a sufficient dose, irradiation can be done.

3.2.1. PTV. The level of dose uniformity of PTV was determined by calculating HI. The HI values in all the patients are shown in Table 2. The smaller of HI value, the higher the uniformity level, and if the value is close to zero, it means that the dose distribution on PTV is almost homogeneous. In all three patients, the HI value is between 0.09 to 0.1. It means that the dose distribution was excellent and almost homogeneous. The oncologists have their considerations in determining the extent of PTV due to the shape, size, and location of the cancer is different for each patient. Excellent radiotherapy planning should avoid hot spots and cold spots as much as possible. One of the methods used is using a bolus with a thickness of 5mm – 1cm on the surface that could solve this problem [14]. The use of this bolus is also not for the entire fraction of irradiation because it can cause a more significant radiation effect on the skin surface, resulting in injury to the skin of the patient.

| Patient | $D_{\text{max}}$ (Gy) | $D_{\text{mean}}$ (Gy) | $D_{\text{min}}$ (Gy) | HI |
|---------|----------------|----------------|----------------|---|
| 1       | 52.38          | 51.08          | 47.60          | 0.09 |
| 2       | 52.68          | 50.37          | 43.36          | 0.18 |
| 3       | 52.22          | 50.20          | 46.71          | 0.11 |

3.2.2. Lungs. The analyzing of lungs was performed by comparing the values of $V_{20}$, $V_{30}$ and the mean dose ($D_{\text{mean}}$) in the right and left lungs for each patient from 3D Slicer simulation. In Table 3, it can be seen the comparison of the dose distribution in the right lung and left lung of all patients. For Patients 1 and 3, the total lung dose was not calculated so that the total lung structure did not appear in DVH. The average doses in Patient 1 for the right and left lungs are still within the recommended tolerance limits from all references, less than 10 Gy [8–10]. However, in Patients 2 and 3, the average dose was still
beyond tolerance. However, the average dose of the total lung is still within tolerance limits. Meanwhile, the $V_{20}$ and $V_{30}$ for the three patients met tolerance limits.

The difference in the radiation dose received by the right lung and the left lung indicates that the cancer is located in the right breast so that the right lung receives a higher radiation dose than the left lung. Since the cancer was on the right side, it was necessary to carry out an analysis for each of the right and left lungs in all three patients. Although in Patients 2 and 3, the average dose received by the lungs exceeds the tolerance, the dose in the right lung will be reduced with the use of a bolus during patient irradiation. The results of OAR analysis of the lungs in three patients, both from the 3D Slicer simulation, showed that the planning met the tolerance limit so that the irradiation can be done.

### Table 3. Lung dose value from 3D Slicer simulation.

| Lung structure | Patient 1 | Patient 2 | Patient 3 |
|----------------|-----------|-----------|-----------|
| $LT D_{\text{mean}}$ (Gy) | 2.32 | 7.09 | 4.05 |
| $LT V_{20}$ (%) | 0 | 0 | 0 |
| $LT V_{30}$ (%) | 0 | 0 | 0 |
| $RT D_{\text{mean}}$ (Gy) | 9.04 | 17.78 | 16.57 |
| $RT V_{20}$ (%) | 11.62 | 29.92 | 27.06 |
| $RT V_{30}$ (%) | 3.99 | 14.90 | 16.03 |
| Total $D_{\text{mean}}$ (Gy) | - | 13.34 | - |
| Total $V_{20}$ (%) | - | 17.48 | - |
| Total $V_{30}$ (%) | - | 8.70 | - |

3.2.3. **Spinal Cord.** The spinal cord is one of the healthy organs that must be protected during cancer irradiation that is made up of nervous tissue with a long tubular structure. It extends from the medulla oblongata in the brainstem to the lumbar region of the vertebrate. Therefore it is necessary to have a tolerance limit for the spinal cord. Dose analysis of the spinal cord was performed by comparing the values of $V_{20}$, $V_{30}$, minimum dose ($D_{\text{min}}$), maximum dose ($D_{\text{max}}$) and mean dose ($D_{\text{mean}}$) in each patient. The tolerance limits in the three references show almost the same values, where the maximum dose received by the spinal cord should not more than 45–46 Gy. In Table 4, for $V_{20}$ it can be seen that for Patient 1, about 7% of her spinal cord volume received a dose of 20 Gy. Patient 2, about 4% of her spinal cord volume, received a dose of 20 Gy. The spinal cord of Patient 3 did not receive a dose of 20 Gy at all of its volume. The best limitation principle for the spinal cord was in Patient 3 because it received the minimum possible dose. However, the three patients met the principle of limitation so that irradiation can be done.

### Table 4. Spinal cord dose value from 3D Slicer simulation.

| Structure of the Spinal Cord | Patient 1 | Patient 2 | Patient 3 |
|-----------------------------|-----------|-----------|-----------|
| $D_{\text{mean}}$ (Gy)     | 5.50      | 9.21      | 3.67      |
| $D_{\text{min}}$ (Gy)      | 0         | 1.68      | 0.59      |
| $D_{\text{max}}$ (Gy)      | 26.29     | 22.53     | 11.12     |
| $V_{20}$ (%)                | 7.88      | 4.59      | 0         |
| $V_{30}$ (%)                | 0         | 0         | 0         |
3.2.4. Heart. The heart is also one of the healthy organs that must be protected when the irradiation process. The heart is located in the right chest cavity, which is the location of cancer in this study. Therefore it is necessary to pay attention to the dose that affects the heart. The dose analysis was also carried out by comparing the values of $V_{20}$, $V_{30}$, minimum dose ($D_{\text{min}}$), maximum dose ($D_{\text{max}}$) and mean dose ($D_{\text{mean}}$) in each patient, as presented in Table 5. The value of $V_{20}$ for Patient 1 was at zero, which means the heart in Patient 1 received a dose smaller than 20 Gy. Meanwhile, Patients 2 and 3 still received a dose of 20 Gy within the tolerance limit requested. For Patient 2, $V_{30}$ accounted for about 3.5%, which means that about 3.5% of her heart volume received the 30 Gy dose. While $V_{30}$ Patients 1 and 3 have a value of zero, meaning that the heart does not receive a dose of 30 Gy at all. Overall the irradiation can be done.

| Heart Structure | Patient 1 | Patient 2 | Patient 3 |
|-----------------|-----------|-----------|-----------|
| $D_{\text{mean}}$ (Gy) | 0.62 | 13.77 | 8.38 |
| $D_{\text{min}}$ (Gy) | 0.13 | 2.08 | 1.35 |
| $D_{\text{max}}$ (Gy) | 4.60 | 45.26 | 33.51 |
| $V_{20}$ (%) | 0 | 17.28 | 2.29 |
| $V_{30}$ (%) | 0 | 3.54 | 0 |

3.3. Comparing DVH 3D Slicer and TPS
The doses compared included the minimum dose ($D_{\text{min}}$), maximum dose ($D_{\text{max}}$), and mean dose ($D_{\text{mean}}$) in each simulation. The percentage of acceptance from the 3D Slicer simulation results on TPS is done by calculating the percentage deviation, then calculating the percentage of acceptance. The smaller value of the percentage deviation means the difference in the value of the 3D Slicer and TPS simulation results is getting smaller so that the more significant percentage of acceptance of the 3D Slicer simulation results to TPS.

For patient 1, shown in Table 6, the maximum dose from the 3D Slicer simulation is 52.73 Gy received by PTV. Meanwhile, according to TPS, the maximum dose is 52.93 Gy, which is also received by PTV. The deviation of the 3D Slicer simulation result value with the largest percentage deviation is 6.54% at the minimum dose of PTV. So that for Patient 1, the smallest percentage of acceptance was 93.46%.

| Structure | Software | $D_{\text{mean}}$ (Gy) | $D_{\text{min}}$ (Gy) | $D_{\text{max}}$ (Gy) |
|-----------|----------|------------------------|------------------------|------------------------|
| PTV       | TPS      | 50.86                  | 43.61                  | 52.93                  |
|           | SLICER   | 50.78                  | 40.76                  | 52.73                  |
| % Deviation |         | 0.16                  | 6.54                  | 0.38                  |
| Lung LT   | TPS      | 2.32                   | 0.13                   | 15.57                  |
|           | SLICER   | 2.32                   | 0.13                   | 15.44                  |
| % Deviation |         | 0.04                  | 0.78                  | 0.83                  |
| Lung RT   | TPS      | 9.03                   | 0.29                   | 48.79                  |
|           | SLICER   | 9.04                   | 0.29                   | 49.07                  |
| % Deviation |         | 0.20                  | 0.05                  | 0.57                  |
Spinal Cord | TPS | 5.52 | 0 | 26.60
| SLICER | 5.50 | 0 | 26.29
| % Deviation | 0.24 | 0 | 1.20

Heart | TPS | 0.61 | 0.127 | 4.60
| SLICER | 0.62 | 0.129 | 4.60
| % Deviation | 1.79 | 1.34 | 0.04

For patient 2 is shown in Table 7, the maximum dose from the 3D Slicer simulation is 54.47 Gy. Meanwhile, according to TPS, the maximum dose is 55.12 Gy. The maximum dose was received by PTV both in the 3D Slicer simulation results and the simulation results from the TPS. This is because PTV is the area where the tumor bundle is located, so it must be given the maximum dose. From Table 7, it can be seen that the largest percentage deviation of the 3D Slicer simulation results against TPS in Patient 2 is 6.14% at the minimum dose of Lung RT so that for Patient 2, the smallest percentage of acceptance is 93.86%.

**Table 7. Percentage deviation of the 3D Slicer and TPS on Patient 2.**

| Structure  | Software | \( D_{\text{mean}} \) (Gy) | \( D_{\text{min}} \) (Gy) | \( D_{\text{max}} \) (Gy) |
|------------|----------|-----------------|-----------------|-----------------|
| PTV        | TPS      | 50              | 20.21           | 55.12           |
|            | SLICER   | 49.96           | 19.12           | 54.47           |
| % Deviation|          | 0.07            | 5.38            | 1.19            |
| Lung LT    | TPS      | 7.09            | 1.54            | 17.40           |
|            | SLICER   | 7.09            | 1.56            | 17.25           |
| % Deviation|          | 0.01            | 0.85            | 0.89            |
| Lung RT    | TPS      | 17.77           | 5.62            | 47.10           |
|            | SLICER   | 17.78           | 5.97            | 46.40           |
| % Deviation|          | 0.08            | 6.14            | 1.48            |
| Total Lung | TPS      | 13.33           | 1.54            | 47.10           |
|            | SLICER   | 13.34           | 1.56            | 46.40           |
| % Deviation|          | 0.07            | 0.85            | 1.48            |
| Spinal Cord| TPS      | 9.24            | 1.71            | 22.41           |
|            | SLICER   | 9.21            | 1.68            | 22.53           |
| % Deviation|          | 0.23            | 1.77            | 0.54            |
| Heart      | TPS      | 13.77           | 2.07            | 45.88           |
|            | SLICER   | 13.77           | 2.08            | 45.26           |
| % Deviation|          | 0.04            | 0.43            | 1.34            |

Meanwhile, for patient 3 is shown in Table 8, the maximum dose from the 3D Slicer simulation is 53.49 Gy. According to TPS, the maximum dose is 53.97 Gy. PTV received both maximum doses. The largest percentage deviation is 3.83% in the minimum dose of the right lung (Lung RT) like Patient 2.
For Patient 3, the smallest percentage of acceptance is 96.17%. The smaller value of the deviation percentage means that the simulation using 3D Slicer approach the simulation using TPS because the deviation is getting smaller. If the deviation of more than 50%, it means the TPS simulation and 3D Slicer simulation is much different so that the simulation of the 3D Slicer result is doubtful [12]. For all three patients, the largest percentage of deviation was Patient 1 of 6.54%, which means that of the three patients, the lowest percentage of acceptance was Patient 1 of 93.46%. However, the percentage of acceptance of all patients using 3D Slicer simulation was above 90% for each structure when compared to TPS.

**Table 8.** Percentage deviation of the 3D Slicer and TPS on Patient 3.

| Structure       | Software | $D_{\text{mean}}$ (Gy) | $D_{\text{min}}$ (Gy) | $D_{\text{max}}$ (Gy) | % Deviation |
|-----------------|----------|------------------------|------------------------|------------------------|-------------|
| PTV             | TPS      | 50.13                  | 36.44                  | 53.97                  | 0.19        |
|                 | SLICER   | 50.04                  | 36.67                  | 53.49                  | 0.63        |
| Lung LT         | TPS      | 4.06                   | 1.01                   | 16.79                  | 0.13        |
|                 | SLICER   | 4.05                   | 1.00                   | 16.71                  | 0.76        |
| Lung RT         | TPS      | 16.57                  | 1.64                   | 50.74                  | 0.01        |
|                 | SLICER   | 16.57                  | 1.58                   | 50.58                  | 3.83        |
| Spinal Cord     | TPS      | 3.70                   | 0.59                   | 11.29                  | 0.84        |
|                 | SLICER   | 3.67                   | 0.59                   | 11.17                  | 0.85        |
| Heart           | TPS      | 8.38                   | 1.34                   | 33.67                  | 0.07        |
|                 | SLICER   | 8.39                   | 1.35                   | 33.51                  | 0.49        |

The difference value in the analysis of distribution dose in 3D Slicer and TPS from the hospital due to the algorithms used are different. The difference in TPS and 3D Slicer algorithms causes differences in translating the volume in each structure so that the dose analyzed is also slightly different. Moreover, the simulation time for each software is different. The comparison between TPS and 3D Slicer on other type of cancer are not much different because for breast cancer mastectomy which has to thin the thorax wall, the difference in value is not up to 10% . The difference in the value of comparing the other type of cancer depends on the different location, size and treatment planning of the tumor.

This study illustrates that the 3D Slicer especially SlicerRT extension has the potential to be used for radiotherapy planning and analyzing in term of learning because the software for TPS in hospitals is usually dedicated to patient treatment. So it is hoped that researchers can use 3D Slicer software for the initial simulations to make radiotherapy planning. This article aims to evaluate dose distribution in breast cancer from the simulation result of TPS and 3D Slicer.

### 4. Conclusion

In the present study, we demonstrated the use of 3D Slicer with SlicerRT for analyzing treatment planning on radiotherapy through the distribution of doses on a dose-volume histogram and calculating
the homogeneity index of dose uniformity and then compared with the simulation results on TPS from the software in the hospital. It was shown that the percentage of acceptance of 3D slicer simulation has an amount value above 90% for each structure from all patients when compared to TPS. Furthermore, the distribution of PTV dose using 3D Slicer simulation from all patients almost homogeneous. The distribution dose of OAR (lungs, spinal cord, and heart) was under the tolerance limit. From these, the conclusion is that 3D Slicer can be used as an alternative software to evaluate the dose of radiotherapy planning results in patients for study and research.

Acknowledgments
This work was supported by the Institut Teknologi Sepuluh Nopember (ITS) and RISTEK-BRIN under Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) (No.1178/PKS/ITS/2020) and MRCCC Siloam Hospital Semanggi Jakarta.

References
[1] Abdi A P Kemenkes: Kanker Payudara & Serviks Paling Banyak di Indonesia tirto.id
[2] Bray F, Ferlay J, Soerjomataram I, Siegel R L, Torre L A and Jemal A 2018 CA: A Cancer Journal for Clinicians 68 394–424
[3] Rakovitch E and Paszat L 2018 The Lancet Oncology 19 1429–31
[4] Podgorsak E B 2005 Radiation Oncology Physics (Vienna: INTERNATIONAL ATOMIC ENERGY AGENCY)
[5] Kikinis R, Pieper S D and Vosburgh K G 2014 3D Slicer: A Platform for Subject-Specific Image Analysis, Visualization, and Clinical Support Intraoperative Imaging and Image-Guided Therapy ed F A Jolesz (New York, NY: Springer) pp 277–89
[6] Pinter C, Lasso A, Wang A, Jaffray D and Fichtinger G 2012 Medical Physics 39 6332–8
[7] ICRU 2010 Prescribing, Recording, And Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT) Journal of the ICRU 10 NP.2-NP
[8] Hu J, Han G, Lei Y, Xu X, Ge W, Ruan C, Chang S, Zhang A and Li X 2020 BioMed Research International 2020 e7131590
[9] Emami B, Lyman J, Brown A, Cola L, Goitein M, Munzenrider J E, Shank B, Solin L J and Wesson M 1991 International Journal of Radiation Oncology*Biology*Physics 21 109–22
[10] Barrett A, Morris S, Dobbs J and Roques T 2009 Practical Radiotherapy Planning (London: CRC Press)
[11] Sharpe M B 2006 I Medical Physics 33 561–561
[12] Regtien P P L, Heijden F van der, Korsten M J and Olthuis W 2004 Measurement Science for Engineers (Elsevier)
[13] Hiswara E 2015 Buku Pintar Proteksi dan Keselamatan Radiasi di Rumah Sakit (Jakarta: BATAN Press)
[14] Park J and Yea J 2016 Cancer radiotherapie : journal de la Societe francaise de radiotherapie oncologique 20 205–9