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Comparative Analysis of OAR and PTV Radiation Dose Achievements for Planning 3D-CRT and IMRT Radiotherapy Techniques for Nasopharyngeal Cancer

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ABSTRACT

A comparison has been conducted between the 3D-CRT technique and the IMRT technique on the radiation dose achievement of Planning Target Volume (PTV) and Organ at Risk (OAR) in nasopharyngeal cancer patients. This study used secondary data in the form of Dose Volume Histogram (DVH) graphs obtained from the results of the Treatment Planning System (TPS). Data analysis was carried out on the dose achievement at PTV with reference to The International Commission on Radiation Units and Measurements (ICRU) Report 62 in 1999, and the dose achievement at OAR with the guidelines of Quantitative Analysis of Normal. Tissue Effects in the Clinic (QUANTEC). The analysis was carried out on 15 nasopharyngeal cancer patients using the 3D-CRT technique and 15 nasopharyngeal cancer patients using the IMRT technique at Ken Saras Hospital, Semarang Regency. The results of the analysis showed that, in the IMRT radiation technique, the percentage of patients who received optimal radiation doses at PTV was 88.9% while for OAR, 11.85% of patients received radiation doses exceeding the QUANTEC tolerance limit. In the 3D-CRT radiation technique, the percentage of patients who received optimal radiation doses on the PTV was only 20% while for OAR, 28.9% of patients received radiation doses exceeding the QUANTEC tolerance limit. The results of the study showed that the IMRT radiation technique is more efficient for nasopharyngeal cancer therapy, because the dose achieved on the PTV is more optimal and the dose on the OAR can be minimized so that the principles of optimization and radiation limitation can be met properly.

Keywords: nasopharyngeal cancer, 3D-CRT, IMRT, PTV, OAR, DVH

INTRODUCTION

Nasopharyngeal cancer (NPC) is caused by the growth of malignant cells that appear in the upper throat and behind the nose [1]. In general, cancer treatment can be done with radiotherapy, which is cancer therapy using ionizing radiation to kill the target, and the modality that can be used is the Linear Accelerator (LINAC). LINAC is a tool that uses high-frequency electromagnetic waves that are very useful for accelerating the movement of electrons so that they can move linearly, thus creating a beam of electrons and energetic photons [2]. Things that need to be prepared before undergoing radiotherapy for cancer patients are to create a Treatment Planning System and Therapy Implementation or Treatment Planning System (TPS). Planning in TPS includes organ contour, setting the radiation angle or beam's eye view display (BEV), and determining dose distribution on the target so that a Dose Volume Histogram (DVH) graph is obtained which shows the distribution of radiation doses for each radiation target. There are two targets in radiation irradiation in TPS, namely Planning Target Volume (PTV) which is the main target for cancer, and Organ at Risk (OAR) or healthy organs around the cancer that are at risk of being exposed to radiation [3]. Several parameters are evaluated from the DVH graph, such as the suitability of the dose distribution to the target shape or conformity index (CI), homogeneity index (HI) or dose homogeneity in the target volume, and radiation dose to organs around the cancer target or Organ at Risk (OAR) [4].

In radiation protection, there are three basic principles that need to be considered, namely justification, optimization, and limitation [5]. The administration of PTV doses is closely related to the principle of radiation optimization, namely the dose to the cancer target must be optimized. Therefore, the administration of PTV radiation doses is regulated in the ICRU Report 62 regulation of (95-107) % which means that PTV receives at least 95% of the dose with a maximum dose of 107%. The dose received by the Organ at Risk (OAR) is related to the principle of radiation limitation, namely the dose received by healthy organs around the cancer target is kept to a minimum. Therefore, the International Society of Radiation Oncology has developed a reference dose that can be tolerated for OAR, namely the Quantitative Analysis of Normal Tissue Effects in the Clinic (QUANTEC) which sets the limit of radiation doses to healthy organs around cancer. In nasopharyngeal cancer, the presence of the tumor is difficult to identify clearly because the anatomy of the nasopharynx is hidden behind the palate and is located at the base of the skull which is connected to many vital organs of the skull [6].

The results of Apriantoro et al.'s research [7] on the analysis of TPS results in the form of DVH and isodose curves stated that there was no difference between the 3D-CRT irradiation technique and the IMRT irradiation technique. However, if we look at the average of both, there is a difference that by using the IMRT technique, the dose received by the organs at risk is more minimal. The results of the study by Tegama et al. [8] also stated that 6 MV X-ray irradiation with the 3D-CRT technique causes complications in healthy tissue around nasopharyngeal cancer because it does not minimize the radiation received by healthy tissue.

Nasopharyngeal Cancer

Nasopharyngeal cancer or in other terms nasopharyngeal carcinoma (NPC) is a malignant tumor that arises from nasopharyngeal epithelial cells. This tumor arises from the lateral wall of the nasopharynx and can metastasize in or out of the nasopharynx to the lateral wall, back wall, base of the skull, nasopharynx, nasal cavity, pharynx and lymph nodes [9]. Early symptoms of nasopharyngeal cancer are conditions that resemble upper respiratory tract infections, sinusitis, or allergies, cases can vary from patient to patient. Patients with early cases of nasopharyngeal cancer usually have symptoms such as unilateral hearing loss and tinnitus. In addition, symptoms in the nose such as bloody mucus discharge, nasal congestion on one or both sides of the nose. Patients suspected of having NPC undergo head and neck examination. Examination of the nasal cavity is performed with a nasal speculum to see the enlargement of the tumor in the nasal cavity. Examination of the oral cavity and pharynx should also be performed to see the extension of the tumor to the pharynx and the presence of trismus. Examination of the neck is performed to detect the presence of nodes, the level, mobility, and size of the nodes should be recorded. The cranial nerves and sympathetic nerves of the neck are systematically examined and all deficiencies are carefully recorded [10].

CT-Simulator

CT-Simulator is a tool for initial examination of the patient's body for diagnostic purposes that utilizes a CT scanner to localize the treatment area based on the patient's CT scan results. The virtual simulation process is assisted by a set of computer programs accompanied by software equipped with a laser that functions as an aid to form a scanning field that will be subjected to radiation. The software that is part of the CT scanner functions to provide an outer layer of external contours, target volumes and critical structures, interactive portal displays and placements, reviews of several processing installations, and isodose distribution displays. Scanning on the CT-Simulator begins by positioning the patient on the patient table until his position is in accordance with the scanning field with the help of a laser. The formation of the scanning field is intended to prevent errors in scanning irradiation so that it avoids the effects of excessive radiation [11].

Treatment Planning System (TPS)

Treatment Planning System or Treatment Planning System and Therapy Implementation in general is a computerized radiotherapy planning system with the help of a computer equipped with software, which is used in the TPS implementation process starting from contouring and data processing to obtain a DVH graph [12. TPS is used in external radiation therapy with the aim of producing beam shapes and dose distributions in patients. TPS itself aims to maximize the dose received by the target (cancer cells) and to minimize the dose to normal tissue around the cancer target [13].

Planning Target Volume (PTV)

Planning Target Volume (PTV) or target volume is a volume that includes Clinical Target Volume (CTV) with Internal Margin (IM) and setup margin (SM) for patient movement and setup uncertainty. In describing PTV, IM and SM are done by combining subjectively rather than adding linearly. The margin in the CTV area in all directions must be large enough to compensate for internal movement and patient movement and setup uncertainty [11. An illustration of PTV is seen in Figure 1

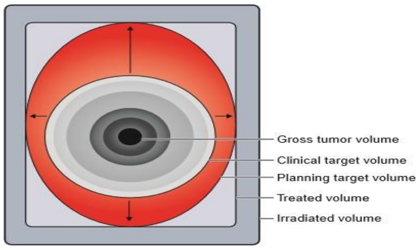


Figure 1. Illustration of PTV (Khan and Gibbons, 2014)

Organ at Risk (OAR)

Planning in radiotherapy must always consider the structure of normal tissue around the cancer site or Organ at Risk (OAR). OAR is considered as an organ that cannot receive large amounts of radiation above the tolerance limit, because damage to a small amount can cause severe clinical symptoms. OAR in nasopharyngeal cancer includes the following: chaism optic, eye lens, brainstem, medula spinalis, parotid glands, oral cavity and esophagus.

Three Dimensional Conformal Radiotherapy (3D-CRT)

Three Dimensional Conformal Radiotherapy is a radiotherapy technique that uses 3D technology, namely using three radiation fields that form radiation beams based on the shape of the tumor, which includes the primary tumor target area, the area at risk of tumor spread, and the area in the planning that takes into account patient shifts. After that, the direction of radiation exposure and the amount of dose in each direction of radiation are adjusted to the shape of the target with the radiation beam used being the same for each direction of radiation. The disadvantage of this 3D-CRT technique is that it cannot estimate the contour in the target tumor manually before the dose is obtained on the computer [14].

Intensity-Modulated Radiation Therapy (IMRT)

Intensity Modulated Radiation Therapy is a radiation therapy technique using multiple radiation fields for the irradiation process. The IMRT technique calculates the target dose and radiation intensity delivered to each radiation target. This technique has a more accurate dose distribution for small-volume tumors in 3-dimensional (3D) form. Isodose curves are obtained to reduce the risk of organ toxicity, and to deliver different radiation doses to the desired location. In addition, the IMRT technique can deliver different radiation doses to each desired location (in 1 PTV). The IMRT technique is generally used to treat complex cancers such as prostate cancer, head cancer, cervical cancer, breast cancer, lung cancer, and nasopharyngeal cancer [14].

Dose Volume Histogram (DVH)

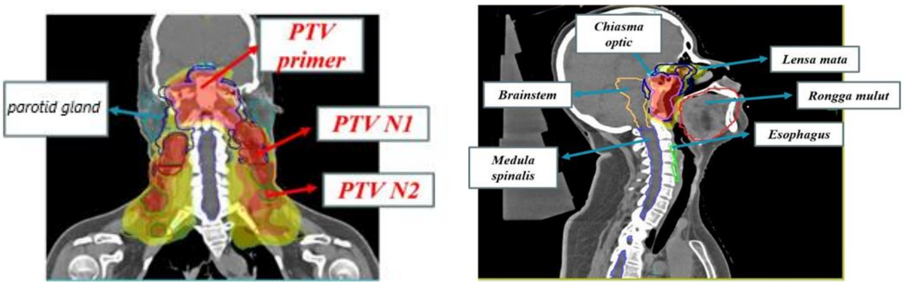
A Dose Volume Histogram (DVH) is a graph that displays the dose distribution as a curve or isodose surface that shows not only areas of uniform, high or low dose, but also their location and anatomical areas.

In this paper, an analysis will be conducted on the achievement of radiation protection received by nasopharyngeal cancer patients at Ken Saras Hospital, Semarang Regency. The analysis was conducted on the achievement of radiation doses received by cancer cell targets (PTV) and healthy organs around cancer (OAR) observed based on the DVH graph.

MATERIALS & METHODS

The study began with the collection of secondary data of nasopharyngeal cancer patients in the form of DVH graphs from TPS results conducted by Medical Physicists on nasopharyngeal cancer patients with 3D-CRT and IMRT radiation techniques. Furthermore, an analysis of the radiation dose received by PTV was carried out with reference to the ICRU Report 62 regulations and an analysis of the dose received by OAR with the QUANTEC guidelines. The tools used for the study were a set of computers with software used in the TPS process and secondary data of nasopharyngeal cancer patients obtained from the hospital. The study began by calculating the dose distribution, data processing, and displaying the results in the form of DVH graphs. TPS for the 3D-CRT irradiation technique used Prowess Panther 5 software with a Siemens LINAC with 6 MV energy. While for the TPS IMRT technique used Monaco software with an Elekta.

Data analysis was performed on the radiation dose values achieved by PTV and OAR, then adjusted to the reference used, namely ICRU Report 62 for the radiation dose achieved by PTV and QUANTEC for the radiation dose received by OAR in each radiation technique. Furthermore, a comparison was made of the dose achieved by OAR and PTV, with 3 PTVs obtained, namely Primary PTV which is the main target of nasopharyngeal cancer, PTV N1 which means the Node 1 area is the second target area of the lymph node classification located in the upper neck near the patient's head, and PTV N2 which means the Node 2 area is the third target area of the lymph node classification located below PTV N1, starting from the lower neck to the patient's shoulder. Meanwhile, the analysis carried out on the radiation dose received by healthy organs around the cancer area (OAR) only focused on seven OARs located close to the cancer target (PTV). The location of the PTV and surrounding healthy tissue (OAR) in nasopharyngeal cancer is shown in Figure 2.



(a) (b)

Figure 2. Anatomy of Nasopharyngeal Cancer
(a) Primary PTV, N1, and N2 (b) OAR

RESULT

Analysis of Radiation Dose Achievement from DVH Graph

This study was conducted by collecting secondary data in the form of DVH graphs from the TPS results of 30 data of nasopharyngeal cancer patients stage T3N2M0. Details: 15 patient data with 3D-CRT radiation technique planning and 15 patient data with IMRT radiation technique planning. For the study, LINAC was used with an energy of 6 MV. Analysis was conducted on the radiation dose achievement received by Primary PTV, N1, N2, and OAR. This study focused on seven OARs, namely the optic chiasm, eye lens, brainstem, spinal cord, parotid gland, oral cavity and esophagus.

The DVH graph obtained shows the coordinates for PTV and OAR, which can be seen in Figure 3.

(a) (b) (c)

Figure 3. Anatomical Location of Nasopharyngeal Cancer in Patients Direction
(a) Coronal, (b) Sagittal, and (c) Axial

The Figure 3 shows the anatomy of nasopharyngeal cancer indicated by purple, red, and green lines for Primary PTV, N1, and N2 respectively. While the other colors indicate the location of the OAR around the cancer target. The radiation dose value received by the patient's PTV and OAR can be seen based on the DVH graph in Figure 4.

Figure 4 shows the DVH graph of patient number 5 with nasopharyngeal cancer with IMRT radiation technique. It can be seen that the purple, red, and green lines indicate the radiation dose to the Primary PTV, N1, and N2 respectively, indicated by a perfectly distributed curve showing a uniform high dose throughout the volume, which is shaped close to the function and a steep slope, indicating that most of the volume in the PTV has the same radiation dose in both the Primary PTV, N1, and N2. Meanwhile, the line that has a concave appearance indicates the radiation dose received by the OAR, indicated by a line with a steep slope. This shows that the radiation dose received by the OAR is relatively small [15]

From Figure 4, it can be seen that the distribution of radiation on several organs that are the target of radiation or PTV received a radiation dose of 98.50% for the dose on the Primary PTV, a radiation dose of 99.77% for the dose received by PTV N1, and 97.04% for the dose received by PTV N2. This means that the value of the dose achieved on the PTV indicates that the patient received a radiation dose in accordance with the ICRU Report 62 regulations.

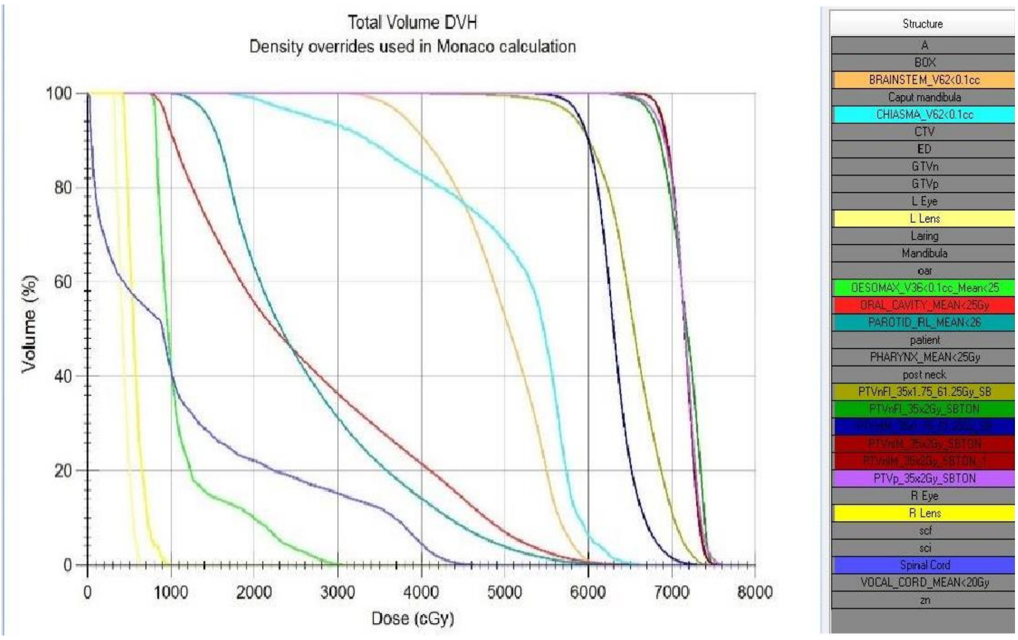


Figure 4 Dose Volume Histogram (DVH) Graph of Patient 5 IMRT

Analysis of Radiation Dose Achievement at TPS with 3D-CRT Irradiation Technique

The value of the radiation dose achieved by PTV and OAR in 15 nasopharyngeal cancer patients using the 3D-CRT radiation technique can be seen in Table 1 and Table 2.

Table 1 Data on PTV Radiation Dose Achievement in Nasopharyngeal Cancer Patients Using 3D-CRT Radiation Technique

Patient Number	Primer		N1		N2	
	Dose (%)	ICRU-62	Dose (%)	ICRU-62	Dose (%)	ICRU-62
1	87.4	x	83.3	x	87,0	x
2	92.0	x	89.5	x	86.7	✓
3	87.2	x	80.0	x	73.7	✓
4	96.1	✓	81.4	x	81.1	x
5	80.9	x	80.7	x	80.7	✓
6	87.3	x	75.9	x	75.9	x
7	94.5	x	80.0	x	72.3	x
8	94.2	x	94.2	x	82.7	x
9	84.0	x	93.3	x	78.4	x
10	82.7	x	93.0	x	86.5	x
11	95.3	✓	99.0	✓	90.6	✓
12	90.6	x	96.3	✓	72.1	x
13	95.0	✓	92.4	x	82.4	✓
14	96.1	✓	88.7	x	96.4	x
15	98.4	✓	96.3	✓	88.7	x

From table 1, it can be seen that each patient received a dose at different PTVs, and many patients received a dose that was less than the ICRU Report 62 at the PTV marked with the symbol “x”. However, there were several patients who received a dose that was in accordance with the ICRU Report 62 marked with the symbol “✓”, with the percentage of patients who received a dose in accordance with the ICRU Report 62 of 20% and the rest, namely 80% of patients received a dose in the PTV that was less than the ICRU Report 62.

Table 2 Data on Radiation Dose Achievement of OAR Nasopharyngeal Cancer Patients Using 3D-CRT Radiation Technique

Patient Number	Chiasm optic		Right Eye Lens		Left Eye Lens		Brainstem		Right Parotid Gland		Left Parotid Gland	
	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk
1	304.8	x	0	x	0	x	6014.7	x	6499.1	✓	7012.5	✓
2	5607.2	x	806.6	x	226.2	x	5994.7	x	6568.6	✓	6762.5	✓
3	5751.8	x	184.7	x	116.6	x	6020.2	x	6682.1	✓	7123.3	✓
4	6284.9	✓	626.9	x	411.5	x	5965.6	x	6163.7	✓	6735.4	✓
5	4221.4	x	0	x	0	x	5964.7	x	6943.0	✓	6873.5	✓
6	4626.0	x	515.0	x	597.5	x	5622.1	x	6714.3	✓	6036.0	✓
7	6271.1	✓	237.0	x	392.8	x	6355.5	x	7030.2	✓	6441.7	✓
8	5911.5	x	203.4	x	0	x	5945.8	x	6673.1	✓	0	x
9	0	x	0	x	0	x	5967.3	x	4715.5	✓	5197.0	✓
10	5852.1	x	393.6	x	340.1	x	5994.7	x	6941.0	✓	7047.0	✓
11	5236.5	x	175.0	x	212.6	x	6198.4	x	7367.1	✓	7159.7	✓
12	6033.5	✓	777.3	x	444.2	x	5969.1	x	7219.1	✓	7218.0	✓
13	720.4	x	119.6	x	0	x	5901.6	x	7089.7	✓	0	x
14	3150.8	x	252.2	x	219.6	x	6314.4	x	6742.1	✓	6620.0	✓
15	6112.7	✓	345.6	x	345.6	x	6235.1	x	7322.9	✓	7130.8	✓

In table 2, it can be seen that in the brainstem organ, all patients received a safe radiation dose or did not exceed the QUANTEC tolerance limit, which is indicated by the symbol "x". Meanwhile, for the right parotid gland and the left parotid gland, all patients received a radiation dose exceeding the QUANTEC tolerance limit, which is indicated by the symbol "✓", this can occur because the 3D-CRT radiation technique forms three radiation fields with the same radiation dose for each radiation direction.

Analysis of Radiation Dose Achievement at TPS for IMRT Irradiation Technique

The value of the radiation dose achieved by PTV and OAR in 15 nasopharyngeal cancer patients using the IMRT radiation technique can be seen in Table 3 and Table 4.

The data in table 3 shows that most patients received radiation doses on the Primary PTV, N1, and N2 in accordance with the ICRU Report 62 regulations, indicated by the symbol “✓”. From the data of 15 nasopharyngeal cancer patients with IMRT radiation techniques, the percentage of patients receiving doses in accordance with the ICRU Report 62 regulations was 88.9%, while 11.1% of patients received doses less than the ICRU Report 62 regulations.

In table 4, it can be seen that there are several patients with the IMRT technique who received a maximum radiation dose (Dmax) that exceeds the QUANTEC tolerance limit, which is indicated by the symbol "✓" and may be at risk of receiving side effects after radiation therapy on the organ. In the brainstem, all patients received a radiation dose that did not exceed the QUANTEC tolerance limit. Meanwhile, in the right parotid gland, patient number 13 did not receive a radiation dose, this is because the location of the PTV tends to be on the left and in the left parotid gland, patients number 1, 8, and 14 also did not receive a radiation dose, this is because the location of the PTV tends to be on the right and the PTV is not close to the left parotid gland so that the patient did not receive a radiation dose to the organ.

Table 3 Data on Radiation Dose Achievement of PTV in Nasopharyngeal Cancer Patients Using IMRT Radiation Technique

Patient Number	Primer		N1		N2	
	Dose (%)	ICRU-62	Dose (%)	ICRU-62	Dose (%)	ICRU-62
1	87.4	x	83.3	x	87,0	x
2	92.0	x	89.5	x	86.7	✓
3	87.2	x	80.0	x	73.7	✓
4	96.1	✓	81.4	x	81.1	x
5	80.9	x	80.7	x	80.7	✓
6	87.3	x	75.9	x	75.9	x
7	94.5	x	80.0	x	72.3	x
8	94.2	x	94.2	x	82.7	x
9	84.0	x	93.3	x	78.4	x
10	82.7	x	93.0	x	86.5	x
11	95.3	✓	99.0	✓	90.6	✓
12	90.6	x	96.3	✓	72.1	x
13	95.0	✓	92.4	x	82.4	✓
14	96.1	✓	88.7	x	96.4	x
15	98.4	✓	96.3	✓	88.7	x

Table 4 Data on Radiation Dose Achievement of OAR Nasopharyngeal Cancer Patients using IMRT Radiation Technique

Patient Number	Chiasm optic		Right Eye Lens		Left Eye Lens		Brainstem		Right Parotid Gland		Left Parotid Gland	
	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk	Dmax (cGy)	Risk
1	518.9	x	192.3	x	240.5	x	5542.1	x	2824.3	x	0	x
2	6476.6	✓	1101.7	✓	1016.2	✓	6378.7	x	4106.0	✓	4069.5	✓
3	6233.9	✓	1219.0	✓	1137.1	✓	6284.8	x	3486.4	x	3476.4	x
4	1940.1	x	749.0	x	967.7	x	5688.2	x	2683.1	x	2683.1	x
5	6603.1	✓	969.9	x	628.2	x	6244.7	x	2650.8	x	2650.8	x
6	1392.4	x	252.3	x	264.5	x	6224.8	x	4154.0	✓	3247.1	x
7	3163.1	x	801.7	x	666.9	x	6172.6	x	3346.1	x	3674.5	x
8	3948.1	x	350.7	x	374.7	x	6244.8	x	3172.2	x	0	x
9	4872.3	x	655.2	x	761.4	x	6157.6	x	3096.6	x	3261.5	x
10	2868.2	x	797.7	x	722.7	x	6155.9	x	5637.8	✓	3323.3	x
11	6103.9	✓	326.7	x	482.0	x	6231.5	x	3160.2	x	3261.7	x
12	4221.5	x	977.5	x	788.6	x	5996.1	x	4254.4	✓	3261.9	x
13	6068.3	✓	340.3	x	268.5	x	6197.3	x	0	x	3253.5	x
14	855.7	x	397.6	x	459.5	x	6041.3	x	3455.0	x	0	x
15	3313.2	x	777.5	x	808.3	x	6026.7	x	3537.0	x	3640.4	x

DISCUSSION

Based on the results of the analysis of 15 patients with stage T3N2M0 nasopharyngeal cancer with 3D-CRT IMRT radiation technique planning, the results of radiation dose achievement on the PTV and OAR were different for each radiation technique. With the 3D-CRT radiation technique, the results of radiation dose achievement for Primary PTV, N1 and N2 were obtained with the percentage of patients receiving optimal radiation doses of only 20%, while the remaining 80% of patients received less than optimal radiation doses. This is not in accordance with the regulations in ICRU Report 62, namely that the dose received by PTV must be optimized so that the principle of radiation optimization can be achieved. Meanwhile, the results of the analysis with the IMRT radiation technique showed that the percentage of patients receiving optimal radiation doses on PTV was 88.9%, while the remaining 11.1% of patients received less than optimal doses.

The amount of radiation dose received by healthy organs around the cancer area (OAR) must be as minimal as possible so that the principle of radiation limitation is met. The results of the analysis explain that each patient receives a different OAR radiation dose in each radiation technique. Patients who receive radiation doses exceeding the QUANTEC tolerance limit on the optic chiasm, right eye lens, and left eye lens may be at risk of experiencing visual disturbances. Patients who receive radiation doses exceeding the QUANTEC tolerance limit for the right or left parotid glands may be at risk of reduced saliva production resulting in dry mouth and chapped lips.

The results of the analysis of OAR of nasopharyngeal cancer patients with 3D-CRT radiation technique, the percentage of patients who received radiation doses exceeding the QUANTEC tolerance limit was 28.9%. Meanwhile, from the results of the analysis of OAR of nasopharyngeal cancer patients with IMRT radiation technique, the percentage of patients who received radiation doses exceeding the QUANTEC tolerance limit was 11.85%.

According to Apriantoro et al analysis of TPS results in the form of DVH and isodose curves in nasopharyngeal cancer patients, stated that the average dose to the PTV can be maximized using the IMRT radiation technique rather than the 3DCRT radiation technique, and for organs at risk (OAR) using the 3D-CRT radiation technique and the IMRT radiation technique there is no difference. However, if you look at the average of both, there is a difference and with the IMRT technique the dose received by organs at risk is more minimal [7].

Planning in the 3D-CRT technique is relatively more time-saving in its planning when compared to the IMRT technique, and in terms of economy this technique is cheaper because the field and Monitor Unit (MU) used are not as many as in the IMRT technique. However, this technique has a drawback, namely in the planning process (TPS), it cannot predict the target tumor contour manually before the dose distribution is obtained on the computer [14]. From the comparison results of the two radiation techniques, it was found that the IMRT radiation technique is more efficient for use in therapy of nasopharyngeal cancer patients at Ken Saras Hospital, Semarang Regency. This is because the IMRT technique has many segments so that it can provide different radiation intensities in each direction of radiation and make the dose received by the target cancer volume (PTV) more optimal. This is in accordance with the ICRU Report 62 regulations, namely the amount of radiation dose received by the PTV must be (95-107) % so that the principle of radiation optimization can be met. In addition, the IMRT technique can also minimize the radiation dose received by healthy organs around the cancer target (OAR), and can achieve the principle of radiation limitation well.

CONCLUSION

The results of the analysis of 15 patients with 3D-CRT techniques and 15 patients with IMRT techniques showed that there were patients who received less than optimal radiation doses on the PTV, namely <95%, which is not in accordance with the ICRU Report 62 regulations. Meanwhile, in the OAR, there were patients who received radiation doses exceeding the QUANTEC tolerance limit on certain organs and were at risk of receiving side effects after radiation therapy. In the IMRT radiation technique, the percentage of patients who received the optimal radiation dose on the PTV was 88.9%, while for OAR, 11.85% of patients received a radiation dose exceeding the QUANTEC tolerance limit. In the 3D-CRT radiation technique, the percentage of patients who received the optimal radiation dose on the PTV was only 20%, while for OAR, 28.9% of patients received a radiation dose exceeding the QUANTEC tolerance limit. IMRT radiation technique is more efficient for radiation therapy for nasopharyngeal cancer patients at Ken Saras Hospital, Semarang Regency.

Declaration by Authors

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