Radiotherapy Treatment Planning Outcomes Assessment for Curative and Palliative Cases with Lung Cancer

Hataw N. Mohammed[1*], Nashwan K. Abdulkareem[2], Samir M. Othman[3]

[1]Master student in Department of Basic Sciences, Biophysics Unit, College of Medicine, Hawler Medical University, Erbil, Kurdistan Region, Iraq.

[2]Assistant Professor, Biophysics Unit, Department of Basic Science, College of Medicine, Hawler Medical University (HMU), and Gasha Technical Institute, Erbil, Kurdistan Region, Iraq.

[3]Assistant Professor, Department of Community Medicine, College of Medicine, Hawler Medical University, Erbil, Kurdistan Region, Iraq.

*Corresponding Address: hataw.najm94@gmail.com

Abstract

Background: Lung cancer is the most common visceral cancer and surgery is the best treatment for this disease, but if the patient is unable to have surgery, radiotherapy will play an important role in treatment. This study aimed to compare the impact of different beam arrangement techniques by using three-dimensional conformal radiotherapy (3D-CRT) on the planning outcomes for curative and palliativepatients with lung cancer. **Methods**: In this study, 15 patients with lung cancer were selected, receiving 7 treatments of 60Gy / 30fr and 8 sedatives of 30Gy / 10fr. Patients were treated with 3D-CRT treatment programming using two-beam techniques and three-beam techniques using 6 and 10 MV energy by the ELECTA INFINITY linear accelerator at the Awat Radiation Oncology Center (AROC) in Erbil. The dose parameters and planned target volume were calculated and the data analysis was performed. **Results**: Investigation of dosimetric indicators between 3 beams and 2 beams and palliative cases and curative cases, it showed that there is a significant difference between PTV coverage, conformity index (CI), homogeneity index (HI) and heterogeneity in indicators between 3 beams and 2 beams and palliative cases and curative cases. **Conclusion**: With the increasing spread of radiotherapy in cancer treatment, due to the curative and palliative benefits of this method, significant developments are taking place in cancer treatment day by day. In cases where surgical methods are not possible, radiotherapy with other treatments improve the quality of life of patients on the one hand and increase the survival of patients on the other hand.

Keywords: Beam arrangement technique; Curative; Lung Cancer; Palliative; Radiotherapy; Three-dimensional conformal radiotherapy

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Introduction

The incidence of cancer imposes a heavy economic, social and psychological burden on people and society. Cancers are on the rise due to population growth and aging, as well as factors such as smoking, physical inactivity and overweight, urbanization and economic development, so that the incidence of various types of cancer is higher in developed countries [1]. Lung cancer was diagnosed as the most common visceral cancer with more than 2 million cases in 2018 and about 1.8 million deaths [2]. More than 1.6 million new cases of lung cancer are diagnosed worldwide each year. Lung cancer is the most common cause of cancer deaths, accounting for about 1.3 million deaths a year, accounting for one in five cancer deaths [3]. Lung cancer is classified into two types of non-small cell lung cancer (NSCLC, 70% to 85%) and small cell lung cancer (20% to 25%) [4]. Non-small cell lung cancer (NSCLC) is the most common type of lung cancer and is divided into squamous cell carcinoma (SCC) and adenocarcinoma (AC) [5]. The five-year mortality rate for lung cancer is between 85% and 90% and the five-year survival rate for the disease is 18%, and approximately 75% of patients with lung cancer have incurable or metastatic cancer at the time of diagnosis [6]. Most often, lung cancer is definitively diagnosed when patients present with symptoms such as pain, severe cough, and weight loss, which indicate that the cancer is advanced [7,8]. Due to the diagnosis of this disease in advanced stages, chemotherapy, radiotherapy and Immunotherapy become important treatments for lung cancer because these patients have lost the optimal opportunity for surgery [9,10]. In advanced and metastatic stages of lung cancer, treatment is performed with the aim of increasing the patient's life or improving the quality of life [11]. At present, surgery is the preferred treatment for lung cancer, but if the patient is unable to have surgery, radiotherapy plays an important role in the treatment of lung cancer [12]. For patients with non-surgical NSCLC, treatment options include radiation therapy (RT), conformal radiation therapy (CRT), RT Curative, and palliative RT [13]. The use of (CRT) versus (RT) alone for the treatment of advanced cancer is supported by French radiotherapy [14]. Over the years, several radiotherapy techniques have been used to treat cancers, including lung cancer, including radiotherapy, guided radiotherapy with imaging, three-dimensional conformal radiotherapy (3D-CRT), and intensity-modulated radiotherapy (IMRT) [15,16]. 3D-CRT was developed in the late 1990s as the preferred treatment for cancer with a significant reduction in toxicity to normal organs compared to two-dimensional conformal radiotherapy (2D-CRT) [17]. The lung is an organ located near vital organs of the body such as the heart and spinal cord. When radiotherapy is used to treat lung cancer, these organs are exposed to toxic radiation, so reducing toxicity is very important in radiotherapy [16]. Nowadays, (3D-CRT) has been considered in clinical studies to reduce the toxicity of radiation [18]. To achieve greater local control and less toxicity, lung cancer is treated with linear accelerators mounted under the gills (LINACs) using non-coplanar 3DCRT and IMRT [19].

In the process of radiotherapy treatment, it is very important and vital to check and monitor treatment plans. For this reason, the treatment result for each patient is influenced by the type and treatment plan, and also different criteria (quantitative and qualitative) are used to evaluate the plan [20].

Dose-Volume Histogram (DVH) to compare the dose received in different organs use. DVH during radiotherapy of the curves the basis of these curves is such that the horizontal axis indicates the amount of dose and the vertical axis of volume percentage Different tissues that received a specific and higher dose it shows what they have done. The evaluation of the calculated dose distribution is often based on dose volume histograms (DVHs), which collapse the 3D dose information in 2D metrics (dose and volume), losing the information on its spatial distribution. Due to this limitation, a slice-by-slice inspection of the dose distribution is recommended to identify potential aspects for further improvement [21].

To analyze and check the uniformity of the dose distribution in the target volume, the homogeneity index (HI) is used. A maximum dose of D2% and a minimum round of D98% for planning target volume (PTV) are obtained from DVH. D2% and D98% are the maximum and minimum doses for 2% and 98% of PTV, and the

lower this homogeneity index (HI), the better the homogeneity of the dose [22].
Conformity index (CI) A useful tool for evaluating the quality of radiotherapy treatment plans It is quantitative and shows the relationship between dose distribution and target volume. If CI < 1, the PTV is under coverage. If CI > 1, the normal tissues receive a high dose. Lastly, if CI = 1, in this case, the prescribed dose conforms to the PTV shape [23].
Therefore, this study aimed to compare the impact of different beam arrangement techniques by using three-dimensional conformal radiotherapy (3D-CRT) on the planning outcomes for curative and palliative patients with lung cancer.

Results

In this study, 15 patients with lung cancer were examined curative method has been prescribed for 7 patients and palliative method for 8 patients. Treatment methods used 3D-CRT were treated using two-beam or three-beam techniques.

Examining the results showed that the average age of people in the Curative group is 64.428 (8.59) and in the Palliative group is 62.375 (7.932), and the average age of the two groups has a significant difference (P ≤ 0.001). Genest examination also showed that 14 patients were male and 1 female and there was a significant difference between the two groups in terms of gender (P ≤ 0.001). Examining the type of lung cancer in the two groups showed that in the Curative group there are 6 NSCLC patients and 1 SCLC patient, and in the Palliative group there are 3 NSCLC patients and 5 SCLC patients, and there is a significant difference between the two groups in terms of the type of lung cancer has it (P ≤ 0.015). Examining the position of tumor showed that in the Curative group, 4 patients were L.L.L lobe and 1 patient was R.L.U lobe, and in the Palliative group, 3 patients were L.L.L lobe and 5 patients were R.L.U lobe, and there was no significant difference between the two groups in terms of the position of tumor

(table.1)

Table.1: characterize demographics and clinical in Curative and Palliative Cases with Lung Cancer

Variable		type of treatment		P – value
		curative cases (60Gy/30fr)	palliative cases(30Gy/10fr)	
Age		64.428±(8.59)	62.375±(7.932)	0.001*
Gender	male	7	7	0.001**
	Female	0	1	
type of lung cancer	NSCLC	6	3	0.016**
	SCLC	1	5	
Position of tumor	L.L.L lobe	4	5	0.362**
	R.L.U lobe	3	3	

*P-value based on t-test

** P-value based on chi-square (fisher exact test)

L.L.L lobe: Left Lung Lower lobe

R.L.U lobe: Right Lung Upper lobe

The results showed that there is adequate coverage in both treatment methods, so that the coverage is 96% PTV in 3-beam and 95% PTV in 2-beam, and the coverage is better in 3-beam treatment method and this difference is significant (P ≤ 0.03). The mean conformity Index CI (0.967±0.011) in 3-beam was different CI (0.956±0.012) in 2-beam (P ≤ 0.01), CI ≤ 1 indicates the better CI of 3-beam and also method of 3-beam is better 2-beam. Also. HI close to zero and zero indicates a better homogeneity index according to this the mean homogeneity index (HI) (0.123±.046) in 3-beam was significant compared to the mean HI (0.178±0.050) in 2-beam (P ≤ 0.004) and Investigation of conformity index (CI) and homogeneity index (HI) indices in both techniques showed that 3-beam indices relatively improved compared to 2-beam in left breast cancer.

Examination of the heterogeneity also showed a significant difference between 3-beam and 2-beam (P < 0.01). Heterogeneity index=1 close to one and one indicates a better Heterogeneity index and it showed the better effect of the 3-beam. While there was no significant difference in the Maximum dose/Gy and Mean dose/Gy in the 3-beam and 2-beam methods***. (Table. 2)***

Table.2: Comparison table between the 3-beams and 2-beams planning treatment

Variable	type of treatment		P – value *
	3 beam	2 beam	
PTV coverage (≥95%)	96.628±(1.162)	95.665±(1.185)	0.03
CI	0.967±(0.011)	0.956±(0.012)	0.01
HI	0.123±(.046)	0.178±(0.050)	0.004
heterogeneity	1.108±(0.035)	1.149± (0.049)	0.01
Max. dose/Gy	47.191± (16.911)	49.563±(18.422)	0.715
Mean dose/Gy	43.869±(15.307)	44.740±(16.062)	0.88

The results showed that there is adequate coverage in both treatment methods, so that the coverage is 95% PTV in palliative cases (30Gy/10fr) and curative cases (60Gy/30fr) , and the coverage is better in palliative cases and curative cases this difference is significant (P ≤ 0.05).The mean conformity Index (CI) (0.966±0.014)) in palliative cases was different CI (0.956±0.012) in curative cases (P ≤ 0.01), CI ≤ 1 indicates the better CI of palliative cases and also method of palliative cases is better curative cases. HI close to zero and zero indicates a better homogeneity index according to this the mean homogeneity index HI (0.131±0.037) in palliative cases was significant compared to the mean HI (0.173±0.064) in curative cases (P ≤ 0.043). Examination of the heterogeneity also showed a significant difference between palliative cases and curative cases (P < 0.02). Heterogeneity index=1 close to one and one indicates a better and it showed the better effect of the palliative cases. There was significant difference in the Max.dose/Gy (D2%) (P ≤ 0.001) and Mean dose/Gy (P ≤ 0.001) in the palliative cases and curative cases which indicates that the maximum received dose and the average received dose it is less in palliative cases***. (Table. 3)*** And based on these results Palliative cases are better than curative

Table.3: Comparison table between curative and palliative cases

Variable	type of treatment		P – value *
	palliative cases(30Gy/10fr)	curative cases (60Gy/30fr)	

PTV coverage (≥95%)	95.530±(1.470)	95.708±(0.785)	0.05
CI	0.966±(0.014)	0.956 (0.007)	0.026
HI	0.131±(0.037)	0.173±(.064)	0.043
Heterogeneity	1.104±(0.032)	1.156±(0.047)	0.002
Max. dose/Gy	32.806±(0.061)	66.144±(6.183)	0.001
Mean dose/Gy	30.525±(0.441)	60.052±(5.443)	0.001

*P-value based t-test

Discussion

In this study, lung cancer patients were examined palliative cases (30Gy/10fr) and curative cases (60Gy/30fr) and method 3-beams and 2- beams. While examining the difference in 3-beam and 2-beam methods and dosimetric indices, the difference in palliative cases and curative cases was investigated.

It should also be noted that according to the effects and consequences of lung cancer for patients, it is estimated that lung cancer alone is responsible for 60,846 years of lost life per year. Also, its financial burden is estimated at 1301 billion dollars during 10 years. Paying attention to these indicators and statistics can be an alarm for both people and health policy makers [24].

When lung cancer is diagnosed, more than 60% of patients are in advanced stages of the disease. Also, patients who are in the early stages of the disease will progress over time and eventually all patients will need medical and palliative treatment [25]. Previous studies have shown that radiotherapy in the treatment of lung cancer, both with curative and palliative goals, increases the median survival of patients. And radiotherapy ultimately improves the quality of life of patients and reduces the complications of the disease such as pain, anorexia and hemoptysis [26].

The investigation of dosimetric indices between 3-beam and 2-beam methods in the present study showed that there is a difference between PTV coverage (>95%), CI and HI and heterogeneity. In Mazloumi et al (2019) study, entitledEvaluation of the Dose Gradient Index in Various Intensity-Modulated Radiation Therapy Techniques in Patients with Optic Nerve Sheath Meningioma [27], There was a significant relationship between the dosimetric indicators, which is consistent with the results of the present study.

The radiotherapy conformity index (CI) is a useful tool to quantitatively assess the quality of radiotherapy curative plans and represents the relationship between isodose distribution and target volume. A conformity index of unity means PTV and minimal unnecessary radiation to surrounding tissues.

A significant difference in CI, HI index and heterogeneity was shown that the 3-beam method and palliative cases method have a better and higher homogeneity index than the 2-beam method and palliative method and a significant difference has been shown in other studies [28,29].

Examining the dosimetric indicators between the intervention with the curative case and the palliative case showed that there is a difference in the indicators of PTV coverage (>95%), CI, HI, heterogeneity index, maximum and mean dose.

The PTV coverage index (>95%) is a geometric concept designed to ensure that the radiation dose is actually delivered to the CTV, which differs between curative and palliative approaches. But it is not clear that this difference is related to which method, which is consistent with the results of the study by Shaverdian et al, (2016) that a significant difference was seen in PTV coverage (>95%) [30].

Also, there was a significant difference in the indices of homogeneity (HI),conformity (CI) , heterogeneity ,maximum and mean dose. It seems that the treatment method has a better homogeneity and compliance index than the palliative method in this study, and the maximum and minimum dose is lower in the treatment method. In the study Pehlivan et al. (2019), entitled "Dosimetric Comparison of Lung-Sparing Radiation Therapy between Volumetric Arc Therapy and Helical Tomotherapy for Unresectable Malignant Pleural Mesothelioma" there was a discrepancy in the dosimetric indices of homogeneity index (HI) and conformity index (CI) and maximum and minimum, which are consistent with the results of this study [31]. Also, these differences in dosimetric indices of homogeneity index (HI) and conformity index (CI) and maximum and mean have been seen in other studies, which are in line with the results of this study [32,33].

It seems that an important and influential factor in the success of curative and palliative radiotherapy is the starting time of the therapeutic and radiotherapy procedures. The results of various studies have shown that the starting time and the interval between the types of treatment methods in lung cancer and other types of cancer are effective and vital in the 5-year survival rate and the reduction of patients' problems [34,35].

Both curative and palliative radiotherapy interventions will cause early and late complications for patients. It may be associated with risks such as the amount of radiation dose, the large volume of tissue that receives radiation, the amount of particle dose, and the toxicity of treatment methods. Curative radiotherapy is performed with the aim of complete removal of the tumor, but palliative radiotherapy is only for managing the symptoms of the disease [36].Lower total time as well as lower total dose is the hallmark of palliative RT [37].

Limitation

Due to the small number of samples in this study, it is recommended that a larger number of patients be examined, and more attention should be paid to the effects and benefits of new treatment methods in prospective studies (cohort).

Conclusion

With the increasing spread of radiotherapy in cancer treatment, due to the curative and palliative benefits of this method, significant developments are taking place in cancer treatment day by day. In cases where surgical methods are not possible, radiotherapy with other treatments can improve the quality of life of patients on one hand and increase the survival of patients on the other hand. Paying attention to the time of disease diagnosis, starting treatment and performing effective and timely interventions can be decisive factors in cancer treatment.

Methods and Materials

Study design

This study is an experimental study conducted at the Awat Radiation Oncology Center (AROC) in Erbil.

Participants

In this study, 15 lung cancer patients who referred to Awat Radiation Oncology Center were included in the study after obtaining written consent. Sampling method was convenience. Inclusion criteria: for all cases were single isocenter technique, and energy 6MV and 10MV. Exclusion criteria: Patients who met the exclusion criteria included those with more than one PTV, and treatment planning that need energy more than 10MV.

Patients with lung cancer, receiving 7 treatments of 60Gy / 30fr and 8 sedatives of 30Gy / 10fr. Patients were treated with 3D-CRT treatment programming using two-beam techniques and three-beam techniques using 6 and 10 MV energy by the ELECTA INFINITY linear accelerator Monaco software (version 5.51.02)Monaco is a treatment planning system (TPS) software produced by Elekta for radiotherapy. It has the ability to calculate 3D, IMRT, Volumetric Modulated Arc Therapy (VMAT), Stereotactic Radio Surgery (SRS), and Brachytherapy plans with high accuracy using the Monte Carlo algorithm (the most accurate dose calculation available) [22] Patients received 60Gy / 30fr and 30Gy / 10fr doses each for 5 days per a week of therapeutic and palliative radiation, then the dose parameters including maximum dose, minimum dose, mean dose and percentage of planned target volume were Treatment programs Monte carlo algorithm were performed and dosimetric analysis (minimum dose, maximum dose, mean dose and planning target volume (PTV) coverage were calculated by using dose volume histogram (DVH), while conformity index (CI) was evaluated by using the following formula:

$$CI = \frac{volumecoveredby\ 95\%\ ofprescribeddose}{volumeofPTV}$$

The D2% represents the maximum dose that will be delivered to 2% of the PTV and D98% is the minimum dose calculated for the 98% of the PTV.

Dose homogeneity index (HI) was calculated based on the formula presented in the report of the 83rd International Association of Radiation Units (ICRU) for the target tissue according to the following equation:

$$HI = \frac{D2\% - D98\%}{D50\%}$$

The values of D2% and D98% for PTVs were obtained from DVH. The D2% represents the maximum dose that will be delivered to 2% of the PTV, D50% is the prescribed 50% dose for PTV, and D98% is the minimum dose calculated for the 98% of the PTV.

Finally, the data analysis was performed as follows

1-comparing PTV coverage (≥95%) between 3beams and 2 beams arrangement.

2- Comparing PTV coverage rate (≥95%) in palliative and curative cases in 3beams and 2 beams arrangement.

3-comparing each (HI, CI, heterogeneity index, Max dose, and Mean dose) between 3beams and 2 beams arrangement.

4- Comparing each (HI, CI, heterogeneity index, Max dose, and Mean dose) in palliative and curative cases in 3beams and 2 beams arrangement.

5- Comparing each (HI, CI, and heterogeneity index.)

With the ideal result which: HI = 0, CI = 1, heterogeneity index = 1

Data analysis

SPSS version 23 statistical software and Student's t-test and on chi-square (fisher exact test) were used for data analysis.

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Author's contributions

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Conflict of interest

The authors have no conflicts of interest to declare.

Data Availability

The authors guarantee that the data of this research will be provided at the request of other researchers.

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