IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 14, Issue 1 Ser. III (Jan. – Feb. 2022), PP 45-49
www.iosrjournals.org

A comparative dosimetric study between IMRT and VMAT for Irradiation of non-small lung cancer

Mohamed I.Soliman, Khaled.M.Elshahat,Wahib.M.Attia
Zagazig Armed forces oncology center

Abstract
Lungs and heart are the significant restricting organ during radiotherapy (RT) lung cancer. This examination analyzed Intensity-Modulated Radiotherapy (IMRT) with Volumetric Modulated Arc Therapy (VMAT) in diminishing the dose to lungs and heart.
Methods: fifteen patients with non-small-cell lung cancer underwent through radiotherapy.
The patients went through four-dimensional computed tomography(4D-CT) in a supine position. The gross target volume (GTV) was characterized as the representation of any gross tumor and lymph nodes included. The CTV was characterized as the potential microscopic diseases surrounding the GTV. The PTV was made by growing the CTV by 0.5 cm. An internal target volume (ITV) was defined as an association of the GTVs from all respiratory movement phases. Delineation of The OARs (an organ at risk) included the lungs, spinal cord, heart, and esophagus.
Results: Each of the IMRT and VMAT techniques had individual points of interest, and thus it may be significant to utilize distinctive planning techniques for different disease classifications and OAR requirements. Volumetric modulated arc therapy (VMAT) given more conformal target coverage and superior saving of organs at risk (OARs), with shorter treatment delivery time and less MUs than IMRT in treating cancers of different sites.
Conclusions: Each of the IMRT and VMAT techniques had person focal points, but the result of this study has appeared that VMAT can diminish the dose to the heart compared with IMRT.
Keywords: *volumetric modulated arc therapy intensity-modulated radiation therapy, radiotherapy, peripheral lung cancer.*

Date of Submission: 08-02-2022 Date of Acceptance: 22-02-2022

I. Introduction

Treatment of non-small cell lung cancer (NSCLC) stays one of the significant difficulties for radiotherapy. Three-dimensional conformal radiotherapy (3D-CRT) has ended up being a promising therapy technique for NSCLC permitting higher dosages to be conveyed to the target by improved shaping of radiation portals and conformal avoidance of normal structures compared with conventional radiotherapy.

Better radiotherapy impacts have been exhibited with the treatment of intensity‑ modulated radiotherapy (IMRT) related to image‑ guided radiotherapy (IGRT) (1). IMRT can improve dose coverage, but it requires a longer treatment time (2‑ 3)

Intensity‑ modulated radiotherapy (IMRT), volumetric modulated arc therapy (VMAT) improved the efficiency of treatment.

However, the longer treatment time in IMRT could expand the distress of the patients during the treatment. Volumetric modulated arc therapy (VMAT) gave more dose coverage and better saving of organs at risk (OARs), with more limited treatment time and fewer MUs than IMRT. a larger volume of lung receiving lower dose ($V5$ and $V10$) in VMAT has been reported [4 ,5) Dose-volume histograms (DVH) boundaries of V 5 have been demonstrated to be the indicators of radiation pneumonitis (6,7).

This study aimed to compare treatment-related toxicity in lung cancer patients between intensity‑ modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT).

II. Methods And Materials

2.1. Patients' Characteristics. Fifteen NSCLC patients who underwent radiotherapy were selected for this study. Fifteen patients with pathologically confirmed locally advanced NSCLC were random.
selected for examination. The patient characteristics were listed in (Table 1). All patients were staged according to the modified 1997 AJCC staging system [12].
The patients went through four-dimensional computed tomography(4D-CT) in the supine position. The gross

target volume (GTV) was characterized as the representation of any gross tumor and lymph nodes included. The CTV was characterized as the potential microscopic diseases surrounding the GTV. The PTV was made by growing the CTV by 0.5 cm. An internal target volume (ITV) was defined as an association of the GTVs from all respiratory movement phases. Delineation of The OARs (organ at risk) included the lungs, spinal cord, heart, and esophagus.

Table I. Characteristics of the patients (n=15). Treatment planning

Characteristics	***Total***
Age(Years)	
Mean	***55***
Range	***38-72***
Sex (no. of patients)	
Male	***11***
Female	***4***
Disease stage	
IIIa	***8***
IIIb	***7***
PTV volume (cm3)	
Median	***525.2***
Range	***148.6-901.8***
Total lung volume(cm3)	
Median	***3637.9***
Range	***4851-2424.6***

Figure (1) Dose statistics in the lungs for 15 patients for IMRT plans (blue) and VMAT plans (orange

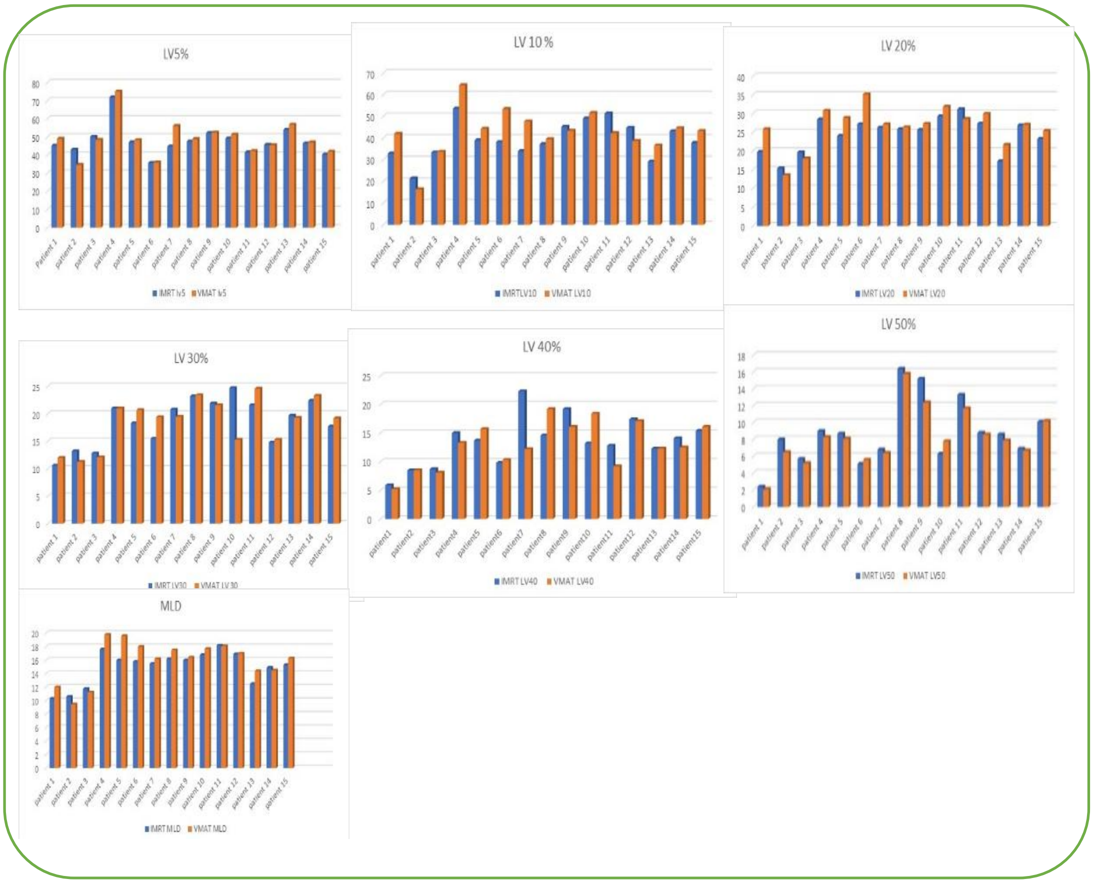

Figure (2) Heart Dose statistics for 15 patients for IMRT plans (blue) and VMAT plans (orange)

IMRT and VMAT plans were planned for each patient. The prescribed dosage to the PTV was 60Gy in 30 fractions. The plans were normalized to cover 95% of the PTV with 100% of the prescribed dose. The optimization targets and limitations were the same for the two methods.. Eclipse 13.6 (Eclipse, Varian) treatment planning system was used for all treatment planning, utilizing 6MV beams and 15MV photon produced from Varian true beam linac equipped with a 120 leaf Millennium Multileaf Collimator (MLC).

IMRT. The beam angles of IMRT were at first optimized by the beam angle optimization algorithm (Varian Eclipse 13.6); a set of starting optimization targets were loaded into the treatment planning system. The number of the fields was limited to five or seven fields. in case the results of the beam angle optimization did not fulfill the dosimetric criteria. The plans were iteratively optimized to get the perfect PTV coverage and Oars sparing. VMAT. All VMAT plans were created utilizing 2 partial or single arcs. The collimator angle changed between 0∘ and 90∘according to the shape of the target. Other planning parameters were MLC movement speed to 2.5 cm/s, gantry turn speed 0.5 to 4.8degrees/s, and dose rate 0 to 600 MU/min.

Plan evaluation and statistical analysis

All clinical records were retrospectively reviewed. Patients and tumor characteristics were collected. To quantitatively measure the organ at risk (OAR) saving for each plan, the following plan parameters were collected from the DVH.

these generated plans compared to each other including V5/10/20/30/40/50 (the percentage volumes which received 5, 10, 20,30,40 and 50 Gy respectively) of lungs, average dose (Dmean) of lungs/heart, V10,20,30,40 and V50 (the percentage volumes which received 30 and 40 Gy respectively) of heart.

III. Results

STATISTICAL ANALYSIS

All data were collected, tabulated, and statistically analyzed using SPSS 22.0 for windows (IBM Inc., Chicago, IL, USA). Continuous Quantitative variables were expressed as the average ± SD Continuous data were checked for normality by using the Shapiro Walk test. Paired t-test was used to compare two dependent groups of normally distributed data while Wilcoxon signed ranks test was used for non-normally distributed data. All tests were two-sided. p-value < 0.05 was considered statistically significant.

RESULTS

DVH parameters	IMRT (n=15) Average ± SD	VMAT (n=15) Average ± SD	Test	p-value
Lung				
V5 (%)	47.74±8.16	49.00±9.63	-1.989[b]	**0.047**
V10 (%)	39.36±8.70	42.79±10.46	-1.859[a]	0.084
V20 (%)	24.53±4.57	26.53±5.41	-2.614[a]	**0.020**
V30 (%)	18.54±4.27	18.53±4.34	0.019[a]	0.985
V40 (%)	13.21±3.97	12.95±4.14	0.283[a]	0.781
V50 (%)	8.75±3.77	8.22±3.31	2.129[a]	0.051
MLD (Gy)	14.95±2.48	15.88±3.02	-2.846[a]	**0.013**
Heart				
V10 (%)	32.14±10.92	30.68±9.80	1.469[a]	0.164
V20 (%)	22.34±10.31	19.18±7.56	3.088[a]	**0.008**
V30 (%)	13.02±6.97	10.78±6.05	3.667[a]	**0.003**
V40 (%)	7.98±6.08	5.86±3.93	3.101[a]	**0.008**
V50 (%)	4a.36±4.57	2.95±2.62	-2.415[b]	**0.016**
MHD (Gy)	11.21±4.62	10.75±4.38	0.986[a]	0.341

a: paired t-test; b: Wilcoxon singed ranks test; p-value< 0.05 is significant (Bold)

Table (2): Comparison between IMRT and VMAT regarding DVH parameters for lung and heart.

A total of 15 patients were included in this study. IMRT plans and VMAT plans were created for each patient. Patient characteristics are given in Table 2. the prescribed dose of the PTV was 60 Gy. The dose-volume histogram parameters for IMRT plans and VMAT plans of 15 patients were compared as shown in Figures 1 and 2. A total of 15 patients were included in this study. IMRT plans and VMAT plans were created for each patient.

The LV5Gy, LV20Gy and MLD were statistically significantly lower (47.74 %vs. 49.00%; p=0.047, 24.53 %vs. 26.53%; p=0.02 and 14.95 %vs. 15.88%; p=0.013 respectively) in IMRT plans than VMAT plans (Table 2). The other remaining factors in the lungs did not contrast between groups.

The result of HV10Gy and MHD showed no statistically significant difference. However, the HV20Gy, HV30Gy, HV40Gy and HV50Gy were statistically significantly lower (19.18% vs. 22.34%; p=0.008, 10.78 % vs. 13.02%; p=0.003, 5.86 % vs. 7.98%; p=0.008 , 2.95% vs. 4.36%; p=0.016) in VMAT plans than IMRT plans (Table 2). The mean heart dose of VMAT plans was 10.75 Gy (range, 3.38 to 18.5 Gy) and this was significantly lower than that of IMRT plans which were 11.21 Gy (range, 3.7 to 20 Gy; p=.341), and the Mean heart dose difference between the two plans was 0.46 Gy.

IV. Discussion

The present study compared dosimetric differences and efficiency of treatment between IMRT and VMAT in NSCLC patients. Cancer-related death can be those because of extreme radiation pneumonitis (RP), esophagitis, or myelosuppression [8]. Although lung cancer is regularly thought to be the reason for death, however treatment-related elements could be deadly.

Several examinations have proposed that the VMAT plan is superior to the IMRT plan in lung cancer. Jiang et al (9) detailed that the VMAT plan gets prevalent PTV inclusion than IMRT plans for privately progressed lung cancer. Jiang et al 10) showed that V20, V30, and MLD of the aggregate and contra- lateral lungs in VMAT plans were essentially lower contrasted and IMRT plans. Different examinations have shown that VMAT plans accomplished the most destinations on track volumes and OARs for stage III NSCLC (11,12). There might be two reasons which lead to the various outcomes. One explanation might be identified with various circumstances of the target volume.

Significant proof backings the commitment of radiation pneumonitis (RP) to mortality of lung cancer patients. In a review assessment of 256 patients who went through radiation treatment for lung cancer, examiners found extreme RP was the lone factor contrarily connected with survival in univariate examinations [13]. The relationship between radiation treatment to lung and extreme RP is grounded [14,15]. Hypothetically, higher radiotherapy dosages could help nearby control in non-small cell lung cancer (NSCLC) patients.

Hypothetically, higher radiotherapy doses could advantage nearby control in non-small cell lung cancer

(NSCLC)patients. In thinking about RTOG 9311, which selected 179 patients with unresectable NSCLC, the dosage of radiation treatment was safely escalated to 83.8 Gy for patients with V20<25% and to 77.4 Gy for patients with V20 between 25% and 36% [16]. This study showed that the VMAT plans come about in significantly superior heart sparing than the IMRT plans utilizing the standard five and seven -beam configuration currently utilized at our hospital. Contrasts in treatment planning between IMRT and VMAT may permit OAR doses and criteria for PTV.

V. Conclusion

In summary, IMRT and VMAT seemed to be suitable for NSCLC treatment. Nonetheless, IMRT could be recommended as the technique of choice when attempting to decrease the risk of radiation-induced pneumonitis This study illustrated that the VMAT superior plans for heart dose compared with IMRT plans utilized for lung cancer treatment. Considering the superior delivery proficiency of VMAT and the fact that the optimized VMAT arrange quality in terms of both DVH and conformality of dose distribution well exceeds that of clinical IMRT plans, VMAT may be another favored methodology for treating lung cancer.

References

[1]. Burnet, N. G., et al. "Practical aspects of implementation of helical tomotherapy for intensity-modulated and image-guided radiotherapy." Clinical Oncology 22.4 (2010): 294-312.
[2]. Studenski, Matthew T., et al. "Clinical experience transitioning from IMRT to VMAT for head and neck cancer." Medical Dosimetry 38.2 (2013): 171-175.
[3]. Pirzkall, Andrea, et al. "Comparison of intensity-modulated radiotherapy with conventional conformal radiotherapy for complex-shaped tumors." International Journal of Radiation Oncology* Biology* Physics 48.5 (2000): 1371-1380.
[4]. Weber, Damien C., et al. "Proton therapy for brain tumours in the area of evidence-based medicine." The British journal of radiology 93.1107 (2020): 20190237.
[5]. Holt, Andrea, et al. "Multi-institutional comparison of volumetric modulated arc therapy vs. intensity-modulated radiation therapy for head-and-neck cancer: a planning study." Radiation oncology 8.1 (2013): 1-11.
[6]. Wang, Shulian, et al. "Analysis of clinical and dosimetric factors associated with treatment-related pneumonitis (TRP) in patients with non–small-cell lung cancer (NSCLC) treated with concurrent chemotherapy and three-dimensional conformal radiotherapy (3D-CRT)." International Journal of Radiation Oncology* Biology* Physics 66.5 (2006): 1399-1407.
[7]. Zoto Mustafayev, Teuta, and Banu Atalar. "Toxicity Management for Thorax Tumors in Radiation Oncology." Prevention and Management of Acute and Late Toxicities in Radiation Oncology. Springer, Cham, 2020. 107-169.
[8]. Tucker, Susan L., et al. "Impact of heart and lung dose on early survival in patients with non-small cell lung cancer treated with chemoradiation." Radiotherapy and Oncology 119.3 (2016): 495-500.
[9]. Yin, Li, et al. "Volumetric-modulated arc therapy vs c-IMRT in esophageal cancer: A treatment planning comparison." World journal of gastroenterology: WJG 18.37 (2012): 5266.
[10]. Jiang, Xiaoqin, et al. "Planning analysis for locally advanced lung cancer: dosimetric and efficiency comparisons between intensity-modulated radiotherapy (IMRT), single-arc/partial-arc volumetric modulated arc therapy (SA/PA-VMAT)." Radiation Oncology 6.1 (2011): 1-7.
[11]. McGrath, Samuel D., et al. "Volumetric modulated arc therapy for delivery of hypofractionated stereotactic lung radiotherapy: A dosimetric and treatment efficiency analysis." Radiotherapy and Oncology 95.2 (2010): 153-157.
[12]. Scorsetti, Marta, et al. "Large volume unresectable locally advanced non-small cell lung cancer: acute toxicity and initial outcome results with rapid arc." Radiation Oncology 5.1 (2010): 1-9.
[13]. Inoue, Akira, et al. "Radiation pneumonitis in lung cancer patients: a retrospective study of risk factors and the long-term prognosis." International Journal of Radiation Oncology* Biology* Physics 49.3 (2001): 649-655.
[14]. Marks, Lawrence B., et al. "Radiation dose–volume effects in the lung." International Journal of Radiation Oncology* Biology* Physics 76.3 (2010): S70-S76.
[15]. Farr, Katherina P., et al. "Development of radiation pneumopathy and generalised radiological changes after radiotherapy are independent negative prognostic factors for survival in non-small cell lung cancer patients." Radiotherapy and Oncology 107.3 (2013): 382-388.
[16]. Bezjak, A., et al. "Intensity-modulated radiotherapy in the treatment of lung cancer." Clinical oncology 24.7 (2012): 508-520.

Mohamed I.Soliman. "A comparative dosimetric study between IMRT and VMAT for Irradiation of non-small lung cancer." *IOSR Journal of Applied Physics (IOSR-JAP)*, 14(01), 2022, pp. 45-49.