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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Comparison of Volumetric Arc Therapy (VMAT) and Helical Intensity Modulated Radiotherapy (Hel-IMRT) in Lung Cancer Radiotherapy

Akciğer Kanseri Radyoterapisinde Volümetrik Ark (VMAT) Terapi Tekniği ile Helikal Yoğunluk Ayarlı Radyoterapi (Hel-IMRT) Tekniğinin Karşılaştırılması

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ABSTRACT

Aim: Definitive radiotherapy is significant in the treatment of locally advanced lung cancer. Various radiotherapy techniques have been developed to preserve critical organ doses while providing better dose coverage to improve the therapeutic index. The aim of this study was to evaluate the differences between VMAT and Hel-IMRT techniques in the treatment of locally advanced lung cancer.

Material and Method:This study was planned to use VMAT and Hel-IMRT techniques with simulation computed tomography data of 15 patients who underwent definitive chemoradiotherapy for locally advanced lung cancer between 01.01.2022 and 01.04.2022. It was planned to compare two different radiotherapy techniques in which continuous irradiation was performed circularly in the treatment of lung cancer. The same user created the plans according to the same dose limitation goal. Target volume coverage and critical organ doses of the patients were recorded.

Results: In the Hel-IMRT technique, the D 95% value for target volume dose coverage was found to be significantly higher (p=0.001). In terms of CI (p=0.001), more optimal values were found with the VMAT technique. There was no significant difference between the two techniques for HI (p=0. 916) and GI (p=0.069).In the data obtained for critical organs, the maximum dose to the spinal cord was found to be statistically significantly lower in the Hel-IMRT technique (p=0.011), the lung dose parameters (V20, V5 and mean dose) in the VMAT technique (p=0.002, p=0.01, p=0.01), and the heart mean dose was lower in the VMAT technique (p=0.002, p=0.01, p=0.01) and the mean heart dose was found to be lower (p=0.012). There is no significant difference between the two techniques for esophageal mean dose and hot spot dose in the plan.

Conclusion: There are different points at which the two different techniques are superior to each other. For this reason, the choice of techniques in treatment planning should be based on patient and clinical factors.

Keywords: Lung cancer, volumetric arch therapy, helical tomotherapy, radiotherapy, toxicity

ÖZ

Amaç: Lokal ileri akciğer kanserinin tedavisinde definitif radyoterapinin önemi büyüktür. Tümör dokusuna yeterli radyasyon dozunu verirken, çevre kritik organları korunmak terapötik indeksi sağlamak ana hedeftir. Bu amaçla farklı radyoterapi teknikleri geliştirilmiştir.

Gereç ve Yöntem: Bu çalışmada Ankara Şehir Hastanesi Radyayon Onkolojisi Kliniğinde 01.01.2022 ile 01.04.2022 tarihleri arasında lokal ileri akciğer kanseri nedeniyle definitifkemoradyoterapi uygulanmış olan 15 hastanın simülasyon bilgisayarlı tomografi verileri kullanılarak iki farklı radyoterapi tekniği karşılaştırılmıştır. Bu amaçla önceden planlama amacıyla çekilmiş GE Discovery marka bilgisayarlı tomografi (BT) verileri kullanılarak Accuray®-Tomotherapy® H™ tedavi planlama sistemi ile Helikal Yoğunluk Ayarlı Radyoterapi (Hel-IMRT) planı, Eclipse™ tedavi planlama sistemiyle Volümetrik Ark Terapi (VMAT) planı oluşturulmuştur. Her iki plan da tez öğrencisi tarafından oluşturulmuş olup PTV D%95 değerinin 5700cGy (Hedef hacim volümünün %95'nin prescribe dozun % 95'ini alması) üzerinde almasına özen gösterilerek kritik organlarda istenilen doz sınırlamaları sağlanmaya çalışılmıştır. Hastane elektronik sistem verileri, hasta dosya bilgileri ve DVH bilgileri kullanılmıştır. Hastalık evresi, tümör lateralizasyonu (sağ-sol), karinaya göre yerleşimi (üst-alt) bigileri kaydedilmiştir.

Bulgular: Tekniklerin karşılaştırılmasında planda oluşan sıcak nokta 0,01cc maksimum doz değeri, kritik organlardan kalp (ortalama dozu), özefagus (ortalama doz, maksimum doz (0,03cc), V60Gy), spinalkord (maksimum doz (0,03cc)) doz bilgileri, hedef hacim sarımı (coverage) değerlerinin yanısıra, gradientindex (GI), homojeniteindex (HI), ve konformaliteİndex (CI) değerleri kullanılmıştır.Verilerin analizinde SPSS Package Program version 23.0 (IBM Corporation, Armonk, NY, USA) kullanılmıştır.Aynı hasta için yapılan iki farklı planının doz verileri karşılaştırılmış olup, bağımlı iki grup analizi için Wilcoxon-SignedRank test kullanılmıştır. İstatistiksel olarak anlamlılık sınır 0.05 'in altı kabul edilmiştir. Hel-YART tekniğinde hedef hacim doz sarımı için bakılan D%95 değeri anlamlı olarak daha yüksek (p=0.001) saptanmıştır. CI (p=0.001) açısından VMAT tekniği ile daha optimale yakın değerler bulunmuştur. HI (p=0.916) ve GI (p=0.069) iki teknik açısından anlamlı farklılık yoktur. Kritik organlar için elde edilen verilerdespinalkord maksimum doz Hel-YART tekniğinde istatistiksel anlamlı daha düşük (p=0.011) saptanmış, VMAT tekniğinde akciğer doz parametreleri (V20, V5 ve ortalama doz) (p=0.002,p=0.01,p=0.01), ve kalp mean dozu daha düşük bulunmuştur (p=0.012). Özefagusdozu ve planda oluşan sıcak nokta dozu için iki teknikte anlamlı farklılık yoktur.

Sonuç: İki farklı tekniğin birbirine üstünlük sağladığı farklı noktalar vardır. Bu nedenle tedavi planlamasında teknik seçiminde hastaya ve kliniğe ait faktörler göz önünde bulundurularak tercih yapılmalıdır.

Anahtar Kelimeler: Akciğer kanseri, helikaltomoterapi, radyoterapi, toksisite, volümetrik ark tedavi

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INTRODUCTION

Despite effective and evolving treatments, lung cancer is the leading cause of cancer-related deaths. GLOBOCAN 2020 data show that 19.3 million people will be diagnosed with cancer and approximately 10 million people will die from cancer (1). Current treatment modalities for lung cancer are more complex than in the past, including radiotherapy, immunotherapy, targeted drugs, chemotherapy, and current surgical techniques. In parallel with better identification of molecular markers and biomarkers than in the past, immunotherapy and personalized treatments have been developed and overall patient survival has improved (2). Despite new agents and changing protocols, RT maintains its place in the treatment of NSCLC. RT can be used for curative and palliative purposes in the treatment of NSCLC and is one of the essential elements of treatment. In 77% of all lung cancer patients, RT is required during treatment (3). Many technological advances have been made in the simulation, treatment planning and delivery phases to improve the application of RT. Modern techniques make it easier to calculate uncertainties in the movement of the tumor. These developments have made it possible to reduce the safety margins allowed for movement. As a result, critical organ doses and side effects have been reduced (4).

Recent advances in computer technology have had a major impact on imaging and the delivery of radiation (5). IMRT provides a more appropriate distribution depending on the tumor and organ at risk (OAR). This is done using a computer-controlled MLC attached to the linear accelerator gantry and treatment planning system (TPS) algorithms. Optimization algorithms are used to find the most appropriate dose distribution.

Volumetric arc therapy uses multiple arcs for each intensity level, and each arc contains multiple MLC segments. The MLC segments move dynamically during the gantry cycle (6,7,8). VMAT differs from IMRT in that the gantry rotates around the patient axis with a cyclic motion during irradiation. The main advantages of VMAT over IMRT are that treatment can be completed in a much shorter time, patient movement is minimized depending on the treatment speed, and treatment accuracy is increased. VMAT uses three variables to modulate the dose. These are gantry speed and dose rate. This technique has been reported to reduce treatment time by 75-80% compared to standard IMRT techniques (7-9).

RT is rapidly moving towards fewer side effects, more effective tumor control, shorter and more targeted treatment programs. After the 2D and 3D treatments used in the past; thanks to technological advances, new and modern techniques have begun to replace these traditional treatments. The main current techniques are IMRT, IGRT, VMAT, helical tomotherapy and SRT. For better RT applications, techniques such as 4D CT, deep breathing inspiration, and simulation CT scans have also been developed. With 3D treatments, treatment times are shorter but may not be sufficient for dose wrap and surrounding critical organ doses. With PTV, IMRT can achieve better dose delivery, but treatment times are longer and there is an increase in low-dose regions. Helical IMRT (Hel-IMRT) is a type of IMRT used in treatments with helical tomotherapy. With Hel-IMRT, rotational dosing is used. Modern techniques have made it easier to understand the uncertainties of tumor movement, resulting in a reduction in the margins that can be achieved. In parallel, a reduction in normal tissue doses has led to a reduction in side effects (10,11). Optimal simulation and RT are still ongoing research topics, and many studies are being conducted.

The aim of this study was to evaluate the dosimetric differences between VMAT and Hel-IMRT techniques in the treatment of locally advanced lung cancer.

MATERIAL AND METHOD

The study used planning and tomography data of 15 patients who underwent definitive chemoradiotherapy for locally advanced lung cancer at the Radiation Oncology Department of Ankara City Hospital between 01.01.2002 and 01.04.2002. Patient records and information from the electronic planning system were used to obtain data. Virtual planning was performed separately. Disease stage, laterality (right-left) and tumor location relative to the carina (up-down) were defined. VMAT and Hel_IMRT techniques were compared for target volume coverage and critical organ doses. (Eclipse and Accuray®-Tomotherapy® H™).

Creation of VMAT plans

The Eclipse™ software used to create VMAT plans. The planning system provides the ability to control dose to target volumes and OARs, while also displaying three-dimensional dose distributions and generating dose volume histograms (DVHs). It uses the Pencil Beam Convolution (PBC) and Analytical Anisotropy Algorithm (AAA) algorithms for photon beams and the Monte Carlo (MC) algorithm for electron beams.The optimization process can be observed and interfered with if necessary while a process algorithm is used to generate the plan (10). In the VMAT treatment plan, the necessary virtual structures were drawn for the target volume and critical organs intersecting the target volume. Two partial arcs were created according to the tumor locations. The 6MV photon was used in the plans and a dose of 60 Gy in 30 fractions was given.

Hel-IMRT plan creation

In the Accuray®-Tomotherapy® H™ treatment planning system, target structures and OARs are assigned to the second tab. Anatomical proximity is ranked in order of importance, taking into account the target dose and dose constraints for OARs (for example, because the heart is closer to the mass in the left lung, it is ranked higher in importance than the right lung). If there is no overlap, the order may vary depending on the user. In tomotherapy plans, target volumes and critical organs were listed and calculated in order of importance (batch beamlet). A treatment plan was then generated according to the desired dose values for the target volume and organs at risk according to the protocol in **Table 1**.

Table 1. Dose constraints used in planning

Structures	Metric	Target value
PTV	V60Gy	≥95%
	Mean dose(D99%)	≥57%
	Maximum dose (0.03cc)	≤72%
Spinalcord	Maximum dose (0.03cc)	≤ 50.0Gy
Lung-GTV	V20Gy	≤34%
	V5Gy	≤60%
	Mean dose	≤18%
Heart	Mean dose	≤20Gy
Esophagus	Mean dose (0.03cc)	≤60Gy
	Mean dose	≤34Gy
	V60Gy	Along the entire wall

Targeted Common Parameters

In both plans, the D95 value for PTV was attempted to be 5700 cGy and (95% of the target volume takes 95% of the prescribed dose) and the desired dose limits were attempted to be provided in the critical organs. Calculations were performed using the AAA algorithm in the newly created plans. The two plans generated for each case (VMAT and Hel-YART) were compared in terms of the following parameters.

Conformity Index (CI): CI Paddick=([(TV²]_PIV))/(PIV×TV))

Homogeneity Index (HI)=(D_(%2)-D_(%98))/D_(%50)

Gradient index (GI)=[PTV]_(%50)/[PTV]_(%100)

PTV coverage: Isodose curve covering the planned target volume.
V5: Lung volume receiving 5 Gy
V20: Lung volume receiving 20Gy
Mean lung dose: Mean lung dose.
Spinal cord _0.03cc and maximum dose: The dose received by the spinal cord in 0.03cc and the maximum dose received by the spinal cord.
Esophagus average and maximum 0.03cc dose: The average dose received by the oesophagus and the dose received in 0.03cc.
Heart mean: The mean dose received by the heart.

Table 2. Results of V5, V20 and PTV_Volume, PTV_Coverage_dose, CI, GI and HI calculated in the helical intensity modulated radiotherapy and volumetric arc therapy plans of the patients.

Patient	Technique	V5	V20	PTV_Volume	PTV_coverage_dose	CI	GI	HI
1	Hel-YART	22.30	7.70	484.12	6013.00	1.21	4.44	0.02
	VMAT	3.95	50.55	348.80	5818.00	0.75	3.1	0.09
2	Hel-YART	53.00	25.20	289.32	6015.00	1.26	5.10	0.03
	VMAT	20.85	45.97	1228.20	6000.00	1.01	4.7	0.07
3	Hel-YART	53.00	33.70	406.24	6016.00	1.39	5.03	0.03
	VMAT	17.28	45.90	1067.70	5857.77	0.82	3.2	0.08
4	Hel-YART	49.40	23.10	231.77	6001.00	1.43	6.81	0.05
	VMAT	17.27	45.90	1067.70	5703.09	1.66	12.0	0.08
5	Hel-YART	58.50	23.40	541.87	5965.00	1.31	3.76	0.11
	VMAT	15.96	56.65	1191.00	5705.21	1.03	3.2	0.07
6	Hel-YART	62.70	23.00	271.70	5974.00	1.21	3.97	0.07
	VMAT	17.62	49.87	991.60	5893.00	0.81	3.5	0.05
7	Hel-YART	50.80	23.60	257.76	5918.00	1.86	6.80	0.08
	VMAT	13.86	42.68	827.40	5720.00	0.58	3.4	0.08
8	Hel-YART	72.70	22.60	224.03	6005.00	1.95	5.30	0.44
	VMAT	16.55	65.12	1139.20	5706.20	0.87	3.7	0.18
9	Hel-YART	55.90	18.80	163.04	5967.00	1.18	4.20	0.11
	VMAT	15.90	33.06	886.10	5710.77	1.01	5.2	0.05
10	Hel-YART	51.80	27.10	412.18	6018.00	1.53	4.97	0.08
	VMAT	16.47	45.08	1029.10	5705.19	1.06	3.8	0.18
11	Hel-YART	63.20	19.60	823.91	6028.00	1.35	4.05	0.05
	VMAT	9.90	64.15	1031.00	5696.60	0.88	3.8	0.05
12	Hel-YART	58.90	30.10	696.57	5965.00	1.39	4.52	0.12
	VMAT	23.54	54.62	1425.30	5701.39	1.98	3.4	0.12
13	Hel-YART	58.40	31.60	572.85	5941.00	1.62	4.78	0.12
	VMAT	29.15	60.77	1767.20	5711.79	1.11	3.7	0.06
14	Hel-YART	56.30	23.90	177.19	5938.00	1.40	6.13	0.14
	VMAT	28.74	51.75	1094.00	5718.53	1.04	4.3	0.08
15	Hel-YART	55.40	19.20	225.95	5978.00	1.14	3.71	0.09
	VMAT	19.12	51.98	1110.90	5704.02	1.03	4.3	0.06

Table 3. Critical organ dose values calculated in two different planning technique

Patient	Technique	Spinal Cord Max dose (Gy)	Heart Mean dose(Gy)	Esophagus Max dose(Gy)	Esophagus Mean dose(Gy)	Esophagus V60Gy
1	Hel-YART VMAT	3803.00 4040.00	54.00 38.30	5352.00 5586.50	1454.00 910.30	0
2	Hel-YART VMAT	1486.00 2030.00	925.00 739.10	4500.00 4395.00	948.00 1589.80	0
3	Hel-YART VMAT	2911.00 3939.00	365.00 176.70	6160.00 6265.00	1936.00 1222.90	0
4	Hel-YART VMAT	2899.00 3984.00	112.00 176.70	2899.00 5720.00	1076.00 880.40	0
5	Hel-YART VMAT	3601.00 4281.00	558.00 626.80	6480.00 6281.00	1955.00 2114.70	0
6	Hel-YART VMAT	4751.00 3384.00	955.00 677.20	6222.00 6040.00	1453.00 1836.70	0
7	Hel-YART VMAT	1295.00 4302.00	1716.00 1088.40	4059.00 2517.93	1486.00 830.70	0
8	Hel-YART VMAT	3315.00 4472.38	1272.00 1085.50	5991.00 5693.03	1061.00 1482.30	0
9	Hel-YART VMAT	2968.00 2989.86	508.00 483.00	5841.00 6210.28	623.00 836.10	0
10	Hel-YART VMAT	4048.00 4353.03	153.00 119.00	6277.00 6100.00	3028.00 2514.10	0
11	Hel-YART VMAT	3505.00 2894.59	1541.00 1343.00	6303.00 6268.73	3584.00 2013.20	0
12	Hel-YART VMAT	929.00 2386.40	1089.00 855.10	5652.00 6066.07	873.00 3167.80	0
13	Hel-YART VMAT	2891.00 4348.17	1609.00 1163.80	6283.00 6066.07	3069.00 3167.80	0
14	Hel-YART VMAT	1095.00 2519.76	306.00 183.70	2966.00 5483.41	572.00 1210.70	0
15	Hel-YART VMAT	1969.00 4042.26	306.00 533.90	5550.00 6289.73	512.00 1402.10	0

Statistical analysis

In this study, planning data were entered using SPSS Package Program version 23.0 (IBM Corporation, Armonk, NY, USA). Descriptive statistics were used for continuous (quantitative) variables; mean, standard deviation, minimum and maximum values were expressed, whereas categorical variables were expressed as numbers (n) and proportions (%). Data from two different schedules for the same patient were compared. The Wilcoxon signed rank test was used for dependent group analysis. For the results of these tests, p≤0.05 was considered to be significant.

RESULTS

The plans were prepared using the same criteria and VMAT and Hel-IMRT techniques were compared. The results of the prepared plans were compared according to the target volumes (GI, CI, HI, V5, V20 and PTV _coverage_volume) and the values specified in the protocol for the organs at risk (Tables 2, 3). The median age of patients was 61 years (range 52-78). Regarding the gender distribution of the patients, 4 (26.7%) were female and 11 (73.3%) were male. The stage of the patients was stage IIB in 4 patients, stage IIIA in 5 patients, stage IIIB in 3 patients, stage IIIC in 1 patient and stage IVA in 2 patients.

In terms of lateralization, seven (46.7%) patients were in the left lung and eight (53.3%) in the right lung. Based on the level of the carina, the tumor localization was divided into 2 groups as upper localization and lower localization. It was observed that most tumors (13 patients 86.7%) were located above the level of the carina. The median planned tumor volume (PTV) of the patients was 289.3 cc (range 163.0-823.9 cc).

When comparing the two plans in terms of target volume dose wrapping, the D value of 95% was significantly higher for the Hel-IMRT technique (p=0.001). On the other hand, the VMAT technique was more advantageous in terms of CI (Conformity Index) (p=0.001). There was no significant difference between the two techniques in terms of Plan HI (p=0.916) and GI (p=0.069) values (**Table 4**).

When comparing the critical organ dose parameters using the Wilcoxon sum rank test, while the maximum spinal cord dose was statistically significantly lower in the Hel-IMRT plans (p=0.011), the dose parameters for the lung (V20, V5 and mean dose) and VMAT with respect to mean heart doses were statistically significantly lower (respectively; p=0. 002, p=0.01, p=0.01 and p=0.012). There was no difference between VMAT and Hel-IMRT techniques in terms of dose parameters (maximum and average dose) and hot spot (0.01cc maximum dose) for the esophagus.

Table 4. Analysis of the difference between the two plans in terms of PTV coverage, HI, CI and GI (PTV: Planned Target Volume, HI: Homogeneity Index, CI: Conformity Index, GI: Gradient Index, Z: score value, P: probability value)

		Hel-IMRT Plan		VMAT Plan		P	Z
PTV_coverage_D95	Mean Median (Range)	5982.80 cGy 5978	33.90 5918-6028 cGy	5756 5710	92.13 5701-6012 cGy	.001	-3.408
PTV_HI	Mean Median (Range)	0.10 0.08	0.10 0.2-0.44	0.08 0.08	0.33 0.05-0.18	.916	-.105
PTV_CI	Mean Median (Range)	1.41 1.39	0.24 1.14-1.95	0.97 1.01	0.23 0.58-1.66	.001	-3.238
Gradient Index	Mean Median(Range)	4.90 4.78	1.00 3.71-6.81	4.40 3.77	2.19 3.19-12.06	.069	-1.818

Table 5. Differential analysis of the values obtained in plans prepared with two different techniques in terms of critical organ dose parameters (Hel-IMRT: helical intensity modulated radiotherapy, VMAT: volumetric arc therapy).

		Hel-IMRT Plan		VMAT Plan		P	Z
Spinal Cord maximum dose (0,03cc)	Mean Median (Range)	2764 cGy 2911	1161 929-4751	3597 3984	824 2030-4472 cGy	0.011	-2.556
Lung-PTV V20	Mean Median (Range)	23.50% 23.4	6.16 7.70-33.70	17.74% 17.27	6.39 3.95-29.15	0.002	-3.067
Lung-PTV V5	Mean Median (Range)	54.86 55.9	10.74 22.30-72.70	49.03 50.55	12.15 17.34-65.12	0.01	-3.181
Lung-PTV Mean dose	Mean Median (Range)	1354 cGy 1362	303 558-1916 cGy	1080 1067	302 348-1767 cGy	0.01	-3.408
Heart Mean dose	Mean Median (Range)	777 cGy 558	581 54-1716 cGy	619cGy 626	424 38-1343 cGy	0.012	-2.499
Esophagus maximum dose (0,03cc)	Mean Median (Range)	5369 cGy 5841	1200 2899-6480 cGy	5679 6066	1007 2517-6289 cGy	0.478	-.710
Esophagus Mean dose	Mean Median (Range)	1575 cGy 1453	968 512-3584 cGy	1601cGy 1482	679 830-3167 cGy	0.820	-.227
Hot point (0.01cc)	Mean Median (Range)	6616 cGy 6562	281 6260-7268	6510cGy1 6500	150 6302-6816	0.427	-.795

DISCUSSION

In this thesis study, using CT images of 15 NSCLC patients who completed their treatment in Ankara City Hospital Radiation Oncology Clinic, Hel-YART and VMAT planning techniques were used by the thesis student with the aim of the same plan objectives. The aim here is to determine the advantages and disadvantages of two different techniques in radiotherapy for lung cancer. According to the results of the study, the two different techniques have different dosimetric advantages. However, the clinical significance of this dosimetric difference in target and critical tissues is unknown.

Tomotherapy uses a different technology to linear accelerators. Thanks to the movement of the tomotherapy table and the 360-degree rotating gantry, the radiation is delivered helically. The VMAT technique is based on the use of more treatment angles, which allows the dose at any point on the target edge to be the same as the dose at the center of the field.

The reduction in treatment time is due to the higher dose rate when using arc techniques and the avoidance of unnecessarily complex MLC positions with the mathematical optimization solution. New treatments for lung cancer include radiotherapy, immunotherapy, targeted agents, chemotherapy and current surgical techniques and are more complex than in the past. In parallel with better identification of molecular markers and biomarkers compared to the past; targeted therapies have been developed and overall survival of patients has improved (11). Despite new agents and changing protocols, the role of RT in the treatment of locally advanced NSCLC remains. RT can be used for both curative and palliative purposes in the treatment of NSCLC. 77% of all lung cancer patients require RT during their treatment course (12). In an article evaluating all lung cancers, an 8.3% increase in local control and a 4% increase in overall survival over 5 years are achieved with the use of RT in the local control of lung cancer (13).

RT is rapidly moving towards fewer side effects, more effective tumor control, shorter and more targeted treatment programs. After the 2D and 3D treatments used in the past; thanks to technological advances, new and modern techniques have begun to replace these traditional treatments. The main current techniques are IMRT, IGRT, VMAT, helical tomotherapy and SRT. For better RT applications, techniques such as 4D CT, deep inspiration breathing, and simulation CT scans have also been developed. With 3D treatments, treatment times are shorter, but may not be sufficient for dose wrap and surrounding critical organ doses. With PTV, IMRT can achieve better dose delivery, but treatment times are longer and there is an increase in low-dose regions. Helical IMRT (Hel-IMRT) is a type of IMRT used in treatments with helical tomotherapy. With Hel-IMRT, rotational dosing is used. Modern techniques have made it easier to understand the uncertainties of tumor movement, resulting in a reduction in the margins that can be achieved. In parallel, a reduction in normal tissue doses has led to a reduction in side effects (14). Optimal simulation and RT are still an ongoing research topic and many studies are being conducted.

Dosimetric studies comparing different techniques have been performed to evaluate which technique is more beneficial in different patient populations. Lung cancer is one such patient population.

In a study by Tang et al. (15); it was found that using a certain number of beam angles in IMRT planning can be effective in providing optimal dose distribution, but the choice of angle is important for the optimal plan. In the IMRT technique, dose adjustment is performed using MLC movements only, whereas in the VMAT technique, dose rate and gantry speed parameters reduce the load on the MLC during dose adjustment, providing fewer MLC movements and thus increasing the accuracy of the calculated plan in practice.

Another area of study is the combined use of different techniques in a single treatment, known as hybrid treatment planning. In a dosimetric study comparing 3D-VMAT hybrid planning and Hel-IMRT, both techniques produced plans that met current guidelines. However, shorter treatments with lower MU were achieved with the hybrid plan; better counter lung, heart and oesophageal doses were achieved (16).

In another comparison of VMAT and IMRT plan, Zhao et al; compared 3 different plans in 15 stage IIIB patients. These; 1. a VMAT plan created with 2 partial arcs, 2. an IMRT plan created with 5 different planes, and finally 3. a hybrid plan created by combining these two plans (17). As expected, lower lung doses at V5, V10, V20 and mean lung were obtained with the hybrid plan compared to the VMAT plan; on the other hand, better critical organ dose protection and lower MU values were obtained compared to the IMRT plan. The researchers argued that the superiority achieved with IMRT was achieved with minimal increases in V5 and V10, and therefore hybrid planning may be beneficial in these cases.

CONCLUSION

The rationale for creating a hybrid plan is to combine the dose conformity provided by VMAT and its advantage in critical organ dose protection with the advantage of low dose area volume reduction achieved with IMRT. This technique can be used in challenging cases. Our study compared two different techniques with continuous irradiation, and the advantage that can be achieved in low dose areas is limited for both techniques compared to static field IMRT plans. The difference in low-dose areas depends on the different planning algorithms, helical and cross-sectional irradiation, and especially on the experience of the physicist who made the plan. The variable depending on the experience of the physicist was tried to be reduced by the PhD student by making both plans and setting specific targets. At the end of the study, significantly lower doses were obtained in the lung low dose area regions and lung-heart mean doses with the VMAT technique. However, no conclusions can be drawn about their clinical significance.

In our study, each patient received a total dose of 60 Gy in 30 fractions. Our results showed that at least 98% of the PTV volume received 95% of the prescribed dose in both techniques. Comparison of the two schedules in terms of dose delivery

The D value of 95% is significantly higher in the Hel-IMRT technique when the time is higher. VMAT was found to be superior in terms of CI. There was no significant difference between the two techniques in terms of HI and GI values. Each technique has its own advantages and disadvantages. For this reason, the choice of technique in treatment planning should be based on patient and clinic factors.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Ankara City Hospital No: 1 Clinical Research Ethics Committee (Date: 29.12.2021, Decision No: E1-21-2198).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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