

Volumetric Modulated Radiation Therapy and Intensity Modulated Radiation Therapy for Lung Cancer: Literature Review

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Abstract Intensity modulated radiation therapy (IMRT) and volumetric intensity-modulated arc therapy (VMAT) are two commonly used modalities to treat lung cancer. VMAT has established increasing interest in treating cancer due to shorter treatment delivery time and less number of monitor units (MUs). The main purpose of this article was to review the relevant current literature on planning studies for lung cancer, with focus on IMRT and VMAT. Additionally, the article aims to point out the different factors, which may influence on the dosimetric results among different planning studies.

Keywords: lung cancer, SBRT, VMAT, IMRT, treatment planning

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1. Introduction

External Beam Radiation Therapy (EBRT), one of the modality to treat cancer patients, has evolved rapidly since last few decades due to its ability in delivering conformal dose to the target while minimizing dose to the organs at risk (OAR). Two of the commonly used EBRT techniques are Intensity modulated radiation therapy (IMRT) and volumetric intensity-modulated arc therapy (VMAT). In IMRT, the beam delivery is done in multiple static fields, whereas the VMAT technique deliver radiation beam by allowing simultaneous variation in gantry speed, dose rate, and multi-leaf collimator (MLC) leaf positions [1,2].

Currently, VMAT has established increasing interest in treating cancer due to shorter treatment delivery time and less number of monitor units (MUs). Several authors have conducted treatment planning studies for lung cancer using VMAT, [2-12] but the findings from these studies are less straight-forward, which does not give a clear choice for the clinicians in selecting one technique over the another. Stereotactic body radiotherapy (SBRT) can be an alternative treatment procedure for the treatment of small lung tumors for non-small-cell lung cancer (NSCLC) patients who are typically ineligible for surgical resection. SBRT allows the delivery of high radiation dose in fewer fractions resulting highly conformal dose distribution to the target.

2. Objective

The main objective of this article was to review the relevant current literature on planning studies for lung cancer, with focus on IMRT and VMAT.

3. Methods

The literature search for this paper was conducted using Google Scholar and PubMed, and relevant articles on VMAT and IMRT for the lung cancer were reviewed.

4. Results

4.1. Literature Review

Several planning studies have utilized VMAT techniques in lung cancer. Bree et al [3] did a planning study in 20 NSCLC patients comparing 3D CRT with dynamic IMRT and VMAT. Conclusion of that study [3] showed that IMRT and VMAT techniques resulted better conformity of the dose distributions in comparison to 3 dimensional conformal radiation therapy (3D CRT). In addition, both the IMRT and VMAT techniques permitted higher dose to the target volume, thus enhancing the regional tumor control. However, there was no significant changes in homogeneity of target dose among VMAT, IMRT, and 3D CRT plans.

In the planning study by Zhang et al [4] on 15 SBRT cases, it was found that relative volume of lung receiving 5 Gy and 20 Gy (V5 and V20, respectively) of lung were lower in the VMAT plans when compared to the ones in the 3D CRT plans. Additionally, target homogeneity was better in the VMAT plans; however, a larger number of

MUs were associated with the VMAT technique when compared with the 3D CRT technique. [4] Scorsetti, et al [5] showed that both the VMAT and IMRT plans had similar dose homogeneity and coverage, with VMAT plans being slightly better at sparing OARs. Ong et al [6] reported that the VMAT technique demonstrated better dose conformity and shorter treatment delivery time when compared to the 3D CRT and IMRT for 18 cases. Furthermore, Ong et al [6] showed that, in comparison to the 3D CRT, the VMAT plans were produced lower V45Gy of the chest wall and higher V5Gy of the contralateral lung. Similar to the lung results of Ong et al [6], Verbakel, et al [7] reported higher V5Gy in the VMAT plans than in the IMRT plans.

Few other studies have shown less dosimetric differences in target coverage between the IMRT and VMAT plans. For instance, Rao, et al [8] reported similar PTV coverage and OAR dose in 8 cases. Similarly, Holt et al [9] showed that the quality of the VMAT was comparable to that of the IMRT in 27 cases. In contrast to the findings of Rao et al [8] and Holt et al [9], Jiang et al [10] demonstrated better PTV coverage in the VMAT plans when compared to the one in the IMRT plan; however, target doses were comparable in these two sets of plans (IMRT and VMAT). Additionally, Jiang et al [10] reported lower mean lung dose, V20Gy and V30Gy of the lung in the VMAT plans, and lower V5Gy and V10Gy of the lung in the IMRT plans. The treatment delivery time was significantly reduced in the VMAT plans [10].

Recently, Merrow et al [11] published a study comparing SBRT VMAT plans with 3D CRT plans for 14 cases and authors evaluated dose to the target and OARs, low dose spillage, and high dose spillage based on the RTOG 0813 and RTOG 0236 protocols. The results from Merrow et al [11] showed favorable dosimetric results using VMAT than using 3D CRT. Rana et al [12] performed a planning study on 16 cases using SBRT VMAT technique and evaluated the dosimetric impact of two dose calculation algorithms: Acuros XB and Anisotropic Analytical Algorithm (AAA). Rana et al [12] reported that the Acuros XB plans produced higher values for V5Gy and V20Gy of lung as well as and higher target heterogeneity, but lower plan conformity and reduced target coverage when compared to the AAA plans.

5. Discussion

Due to the advancement in the treatment delivery techniques and sophisticated treatment planning systems (TPS), which include dose calculation and optimization algorithms, we have noticed an increased number of published articles on the treatment planning studies. However, dosimetric results of one study may be contradictory to the ones in other studies. For instance, Rao et al [8] concluded that IMRT produced lower (or better) V20Gy of lung; whereas Verbakel et al [7] reported comparable V20Gy of lung in both the IMRT and VMAT plans. Several factors could affect the quality of dose distributions in the treatment plans. For example, the VMAT plan generated in the Eclipse TPS may provide different results from that of the VMAT plan in the Pinnacle TPS. Dose calculation algorithms within the TPS can produce a significant impact on the final dosimetric

outcome. This has been shown in the study by Rana et al for SBRT lung cases [12] and other studies [13-19], which demonstrated that the accuracy of dose calculation algorithms is very critical when low-density heterogeneity and small field sizes are present in the photon beam path such as in the case of SBRT lung treatment. Inaccurate dose prediction by dose calculation algorithms will typically lead to dose over-estimation or dose under-estimation during the treatment, which may produce unfavorable impact on the patient treatment outcome.

Most of the planning studies reported in this paper are from different institutions, and this can bring variations in the treatment planning technique among different institutions. In VMAT (or IMRT) planning, dosimetric results performed by the same treatment planner may vary depending on the number of arcs (or fields) to generate the treatment plan. Studies have shown that an extra arc in the VMAT plan could help in reducing dose to the OAR due to an increased number of control points in the overall treatment plan. Furthermore, familiarity of a treatment planner with the plan optimization interface, especially for the VMAT and IMRT, will affect the dose distribution in the treatment plans. For example, in the Eclipse plan optimization interface, the treatment planner can select preferred values for dose-volume objectives and weighting of the tissues in order to meet the dosimetric criteria, and final dosimetric results can be adjusted by varying the optimization parameters [20].

6. Conclusion

Although differences are observed among different treatment planning studies comparing VMAT with IMRT and 3D CRT, the common findings was that the VMAT has a clear dosimetric advantage over the 3D CRT, and the VMAT requires less number of MUs and shorter treatment delivery time when compared to the IMRT. The use of VMAT to treat lung cancer is very promising; however, there is still a need to perform the clinical trials for SBRT VMAT lung cases by incorporating more accurate dose calculation algorithms for dose computation in the patient treatment plans.

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