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Volume Modulated Arc Therapy in Head & Neck Cancer: An A.H. Regional Cancer Centre Experience

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Abstract
Introduction: *In management of head and neck cancer, radiotherapy plays an integral role. IMRT is an established modality in radiotherapy which helps in better coverage of target volume and lower dose to critical structures which leads to lesser toxicity. Volume Modulated Arc Therapy (VMAT) offers a good alternative to IMRT with less treatment time and similar treatment outcome. In this study we have compared conformity, toxicity and treatment time of VMAT with IMRT in head and neck cancers.*
Objective
1. *To determine dose, plan evaluation, (monitor units) MU, optimum target volume coverage with sparing of critical structures and overall treatment time in Head & Neck cancer using VMAT*
2. *To review literature regarding benefit of VMAT over IMRT in head and neck cancer.*

Material and Method: *60 patients of Head and Neck cancers treated with Radiotherapy using VMAT were analysed.*
Result: *Out of the 60 patients, 77% and 23% patients received a total dose of 70Gy and 66Gy respectively. Patients who received a total dose of 66Gy, the mean of dose receiving 95% volume was 66.5Gy. The average Monitor unit and treatment time were 993.8 and 4.2 minutes respectively. Those received 70Gy, mean of dose receiving 95% volume of PTV was 70.3Gy. Here the average Monitor unit and treatment time were 996.7 and 4.3 minutes respectively. The does received by parotid, brainstem and spinal cord were similar when compared with data available to IMRT planning.*
Conclusion: *VMAT provides similar conformity and toxicity as IMRT with less treatment time and less MU. This leads to a greater number of patient treatments in high volume centers.*
Keywords: *VMAT, Head and Neck Cancers, Treatment Time.*

Introduction

Head and Neck cancer is one of the most common cancers in several regions of the world. The annual incidence of head and neck cancer is more than 550,000 cases with around 3 lakh deaths occurring each year(1). The majority of the head & neck cancers occur in India. Asia accounts for around 57.5% of global head and neck cancers

most of which occur in India, the incidence is over 200,000 cases each year[2]. The multimodality approach is the standard treatment for head and neck cancer, out of which radiotherapy plays a crucial role. In sites like nasopharynx, oropharynx, hypopharynx, and larynx, where surgery is not feasible, radiotherapy is the radical treatment. But in oral cavity sites, the treatment of choice is adjuvant radiotherapy. Also in locally advanced oral cavity cancers or if surgery is not feasible due to some comorbid medical reasons, radiotherapy becomes the radical treatment of choice. In the recent era, due to the advancement in imaging and technology, the main radiotherapy technique for head and neck cancer is intensity-modulated radiotherapy (IMRT). IMRT helps in better coverage of target volume with a lower dose to critical structures which leads to potentially less toxicity[3]. On the other hand, volumetric modulated arc therapy (VMAT) is another radiotherapy technique that provides similar conformity, better homogeneity, and result, with better OAR sparing and lesser treatment time[4]. Hence VMAT confers the same advantage of radiotherapy as that of IMRT, but takes less treatment time, allowing more patients to be treated in a limited period. This is helpful in centers like ours where the patient burden is very high and facilitates increased patient turnover.

Aims and Objective

(1) To determine various parameters like dose, plan evaluation, (monitor units) MU, optimum target volume coverage with sparing of critical structures, and overall treatment time in Head & Neck cancer using Volumetric modulated arc therapy (VMAT).
(2) To review the literature regarding the benefit of VMAT over IMRT in head and neck cancer.

Material and Method

60 patients of varying age and sex of head & neck cancers who attended our center from 2018 to 2019 were included in the study. All the patients were treated with Radiotherapy using VMAT technique.

Radiotherapy

Immobilizations of patients were done with thermoplastic masks, in the supine position from the vertex to shoulders. 2-mm slice thicknesses of planning CT images were taken from vertex to the carina with an injection of iodinated contrast medium in all eligible patients. Then the image was transferred to the contouring station, where contouring was done for both targets and OARs; the image was transferred to the treatment planning system and treatment plans were calculated using the Monaco Treatment Planning System. The PTV D95%, PTV D5%, MU, treatment time and dose to OARs (like parotid, brain & spinal cord) were calculated.

Chemotherapy

Eligible patients were administered with systemic chemotherapy i.e. weekly Cisplatin with a dose of 40mg/m^2 during radiotherapy as per protocol.

Observation and Result

60 patients of Head and Neck Cancers were treated with VMAT technique of which 68% were males and 32% were females. The age range of our study population was 8 years to 75 years. The majority belonged to age more than 50 years which is 83% of the study population. Out of 60 patients, 17% had Oral cavity cancer, 13% had Nasopharyngeal cancer, 28% had Oropharyngeal cancer, 28% had Hypopharyngeal cancer and 5% had Laryngeal cancer. The majority of patients in the study population i.e. 85% belonged to either T2 or T3 primary tumor grouping and 87% belonged to N1 or N2 regional nodal grouping. Out of 60 patients, only 10% were treated with Radiotherapy alone without any concurrent chemotherapy and 70% of the study population received 4 to 5 cycles of concurrent cisplatin.

Out of 60 patients, 77% received a total dose of 70Gy and 23% received a total dose of 66Gy. Among patients who received a total dose of 66Gy, (table-1) the mean of dose receiving 95% volume of PTV (PTV D95%) was 66.5Gy and the

mean of dose receiving 5% volume of PTV (PTV D5%) was 67.8Gy. Here the average Monitor unit (MU) was 993.8; the average treatment time was 4.2 minutes. The mean patient 'in and out' time from the machine was 12.8 minutes.

Again, among patients who received a total dose of 70Gy, (table-2) the mean of dose receiving 95% volume of PTV (PTV D95%) was 70.3Gy and the mean of dose receiving 5% volume of PTV (PTV D5%) was 72.8Gy. Here the average Monitor unit (MU) was 996.7; the average treatment time is 4.3 minutes. The mean patient 'in and out' time was 13.1 minutes.

For patients receiving 66Gy, (table-1) the mean of dose receiving 50% volume of the right parotid (D50%) was 28.8Gy, and mean of dose receiving 50% volume of left parotid was 28.0Gy. Again, the mean of the dose received by 1cc volume of Brainstem was 47.2Gy and that of the spinal cord was 37.8Gy.

For patients receiving 70Gy, (table 2) mean of dose receiving 50% volume of the right parotid (D50%) was 27.9Gy, and mean of dose receiving 50% volume of left parotid was 27.8Gy. Again, the mean of the dose received by 1cc volume of Brainstem was 45.1Gy and that of the spinal cord was 36.4Gy.

Table 1- Various parameters of the Patient receiving a total dose of 66Gy.

Site	No. of patient N= 60	No of pt receiving 66 Gy	PTV D95% (Gy)	PTV D5% (Gy)	MU	Treatment time in minute	In and out time	Rt Parotid D50% (Gy)	Lt Parotid D50% (Gy)	Brainstem D1cc (Gy)	Spinal cord D1c0c (Gy)
Oral cavity	10	5	66.7	67.6	1001.4	4.2	12.2	27.6	27.2	46.7	36.5
Nasopharynx	13	1	66.9	67.3	1108.0	4.5	12.0	29.6	28.4	50.2	36.0
Oropharynx	17	4	66.2	69.1	998.8	4.2	13.0	29.2	27.9	44.2	37.7
Hypopharynx	17	3	66.6	67.7	962.7	4.2	13.7	28.0	28.0	46.3	41.3
Larynx	3	1	66.1	67.3	898.0	4.0	13.0	29.6	28.4	48.5	37.3
mean			66.5	67.8	993.8	4.2	12.8	28.8	28.0	47.2	37.8

Abbreviation- Rt-right, Lt-left, MU- monitor unit, Gy-Gray

Table 2- Various parameters of the Patient receiving a total dose of 70Gy.

Site	No. of patient N=60	No of pt receiving 70 Gy	PTV D95% (Gy)	PTV D5% (Gy)	MU	Treatment time in minute	In and out time	Rt Parotid D50% (Gy)	Lt Parotid D50% (Gy)	Brainstem D1cc (Gy)	Spinal cord D1cc (Gy)
Oral cavity	10	5	70.2	72.7	979.0	4.2	12.6	26..4	28.4	45.6	38.5
Nasopharynx	13	12	70.2	72.8	972.2	4.2	13.8	27.9	27.9	47.3	33.3
Oropharynx	17	13	70.2	72.5	1010.2	4.3	13.7	28.1	28.0	46.7	36.8
Hypopharynx	17	14	70.4	72.6	1004.8	4.3	12.6	17.7	28.1	39.9	35.9
Larynx	3	2	70.4	73.3	1017.5	4.6	13.0	29.5	26.5	45.1	37.5
mean			70.3	72.8	996.7	4.3	13.1	27.9	27.8	45.1	36.4

Abbreviation- Rt-right, Lt-left, MU- monitor unit, Gy-Gray

Discussion

The present study was conducted on sixty patients of Head and Neck cancer who attended Acharya Harihar Regional Cancer Centre, Cuttack from the period 2018 to 2019. In this study, patients were treated with radical concurrent chemoradiotherapy by VMAT technique along with weekly injection Cisplatin at a dose of 40 mg/m^2 throughout treatment, the results were compared with the published literature.

In our study, the mean age was 58.4 years and the median age was 58.5years. About 83% of the study population was above 50 years. This is supported by George S Stoyanov et.al.[6], where the mean age of diagnosis was 63.84 ± 12.65 years and the median age was 65 years. According to John Andrew Ridge[7], the incidence of head and neck cancer increases with age, especially after 50 years and most patients were between 50

and 70 years old. This is also consistent with our study.

In the present study, there were 68% males and 32% females. The male to female ratio was 2.2:1, which is lower than the study by George S Stoyanov et.al.[6] where it was 3.2:1. According to John Andrew Ridge[7], the male-female ratio is currently 3:1.

Out of 60 patients, 77% received a total dose of 70Gy and 23% received a total dose of 66Gy. Among patients who received a total dose of 66Gy, (table-1) the mean of dose receiving 95% volume of PTV (PTV D95%) was 66.5Gy and the mean of dose receiving 5% volume of PTV (PTV D5%) was 67.8Gy. Again, among patients who received a total dose of 70Gy, (table-2) the mean of dose receiving 95% volume of PTV (PTV D95%) was 70.3Gy and the mean of dose receiving 5% volume of PTV (PTV D5%) was 72.8Gy. It was clearly shown that the PTV coverage was adequate with VMAT planning.

According to Studenski et al.[5], the dosimetric comparison showed a minimal difference between VMAT and IMRT plans in terms of PTV coverage. According to M. Kryger et al. the PTV coverage was not significantly different between IMRT and VMAT[8].

With dose 66Gy (table-1) the average monitor unit (MU) was 993.8 and with dose 70Gy (table-2) the average monitor unit (MU) was 996.7.

According to Verbakel et al.[9], the average MU in IMRT planning is 1108, and that of VMAT planning is 439. When compared with this study, the average monitor unit for VMAT in our study was higher than that in this study. But the MU for VMAT in our study is certainly lower than that of IMRT in this study.

With dose 66Gy (table-1) average treatment time is 4.2 minutes and with dose 70Gy (table-2) average treatment time is 4.3 minutes.

According to Studenski et al.[5], the average treatment time for IMRT planning was 21.3 minutes. The treatment time was reduced by 9.2±3.9 minutes for VMAT over IMRT, an average reduction of 51.4±15.6%. The maximum time reduction was 15 minutes (78.8%) and the minimum was 2.9minutes (17.5%). By comparing with the average time taken in IMRT planning of this study, there was a 79.8 % reduction in treatment time taken in our study. According to Moret et al.[10] also, there is a significant reduction in treatment time in VMAT as compared to IMRT.

For patients receiving 66Gy, (table-1) the mean of dose receiving 50% volume of the right parotid (D50%) was 28.8Gy and that of the left parotid (D50%) was 28.0Gy. Again, for patients receiving 70Gy, (table-2) the mean of dose receiving 50% volume of the right parotid (D50%) was 27.9Gy and that of left parotid was 27.8Gy.

According to Jingjiao Lou et al.[11], The objective parameter used in IMRT optimization for the Parotid gland was at least one Parotid gland D_{mean}< 26Gy or D_{50} < 30 Gy. In our study, we can see that the average D50 dose to individual parotid is lower than that of recommended value i.e. 30Gy.

For patients receiving 66Gy, (table-1) the mean of the dose received by 1cc volume of Brainstem (D1cc) was 47.2Gy and for patients receiving 70Gy, (table-2) the mean of the dose received by 1cc volume of Brainstem (D1cc) was 45.1Gy.

According to Lawrence B. Marks et al.[13], and Charles Mayo[14] the recommended dose receiving 1cc of the brainstem is ($D_{1–10\ cc}$) ≤59Gy. Hence in our study, we had achieved a lower dose to brainstem which was lower than the threshold limit. Also according to Cheng-Yun Yao et.al[12], the average D1cc for Brainstem was 57.5Gy. In this study also they had achieved a lower dose to brainstem with VMAT planning than the recommended dose.

For patients receiving 66Gy, (table-1) the mean of the dose received by 1cc volume of the spinal cord (D1cc) was 37.8Gy, and for patients receiving 70Gy, (table-2) the mean of the dose received by 1cc volume of the spinal cord (D1cc) was 36.4Gy.

According to John P. Kirkpatrick et al.[15], Using conventional fractionation of 1.8–2 Gy/fraction to the full-thickness cord, the estimated risk of

myelopathy is <1% and <10% at 54Gy and 61Gy respectively. Here we had achieved a dose to spinal cord much lower than the recommended dose.

Conclusion

VMAT planning leads to excellent target coverage and normal tissue sparing, with treatment delivery completed in less than 5 min. VMAT is currently our standard technique for advanced Head and Neck cancer which can be done in significantly less time. Hence VMAT has an advantage over IMRT in high volume centers as this may lead to the treatment of a larger number of patients in a shorter period.

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