IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 14, Issue 7 Ver. VIII (July. 2015), PP 17-20
www.iosrjournals.org

Study of Dose to Organs at Risk in Head and Neck Cancer Treated with Volumetric Modulated Arc Therapy (VMAT)

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Abstract: *Treatment of head and neck cancers with radiotherapy are quite challenging due to complex anatomical structures i.e. the clinical target volume (CTV) is in the contiguity with organs at risk such as brain, eyes, optic nerves, larynx, oropharynx, parotids etc. which are to be preserved. Conventional radiotherapy of head and neck cancer designed to cover target volume results significant dose to the organs at risk. Revolutionary technology such as Intensity Modulated Radiotherapy (IMRT), Volumetric Modulated Arc Therapy (VMAT) improving the therapeutic ratio by minimizing dose to organs at risks without compromising dose to tumour In the present study 10 patients with carcinoma of head and neck region with age from 28 to 65 years treated with VMAT has been considered. Prescribed dose to tumour was 60 to 70Gy (Gray) depending on the clinical parameters of disease. Fractionation scheme was 2.0Gy per fraction, with daily fractionation and 5 fractions in a week. Mean dose to organs at risk were evaluated in the present study. Considerable variation in mean dose to each critical organ was found from one patient to another. Mean dose to brain was found to be varied from 3.0Gy to 7.3Gy, similarly to larynx from 19.8Gy to 55.2Gy, oropharynx from 12.8Gy to 47.6Gy, left eye from 5.2Gy to 9.7Gy, right eye from 9.8Gy to 10.9Gy, left optic nerve from 3.8Gy to 8.6Gy, right optic nerve from 5.7Gy to 10.3Gy, left parotid from 5.6Gy to 29.4Gy and right parotid from 13.5Gy to 45.3Gy. Minimum mean dose was achieved in carcinoma of locally advanced diseases for organs at risk anatomically distant from target volume while maximum mean dose to organs at risk were found with extensive advanced disease. Use of VMAT significantly reduces dose to the critical organs without compromising dose to the tumour in the treatment of head and neck cancers. It results better loco-regional control with minimal normal tissue complication and hence comparatively better quality of life to the patients with head and neck cancer.*

Keywords : *Head and Neck Cancer, Progressive Resolution Optimizer, Volumetric Modulated Arc Therapy.*

I. Introduction

Head and neck cancer constitute 5-50% of all cancer globally [1]. Two third of oral and pharyngeal cancer (excluding nasopharynx) occurs in developing countries [2]. Patients in developing countries are more likely to present with advanced stage [3, 4]. In India, head and neck cancers are common and accounts for about 30% of cancer in male and about 13% in females [5]. Head and neck cancers in India have distinct demographic profile, risk factors, food habit, family and personnel history [6]. Radiotherapy (RT) is the prime modality of treatment for head and neck cancers. However chemo-radiotherapy has been shown to be definitive in the treatment of head and neck cancers [7]. It is estimated that 74% of patients of head and neck cancer need curative radiotherapy either as radical treatment or in the post operative adjuvant setting [8]. Treatment of head and neck cancers with radiotherapy are quite challenging due to complex anatomical structures i.e. the clinical target volume (CTV) is in the contiguity with organs at risk such as brain, eyes, optic nerves, larynx, oropharynx, parotids, etc. which are to be preserved. The quality of life can be further worsened by treatment of head and neck cancer which can induce additional mutilation [9]. Conventional radiotherapy of head and neck cancer designed to cover target volume results significant dose to the organs at risk. Advanced radiotherapy technique, Intensity Modulated Radiotherapy (IMRT) for patients with early stage nasopharyngeal cancer showed a significant benefit over conventional RT on salivary function and quality of life of patients [10, 11]. Revolutionary technology such as Intensity Modulated Radiotherapy (IMRT), Volumetric Modulated Arc Therapy (VMAT) improving the therapeutic ratio by minimizing dose to organs at risk without compromising dose to tumour. In the present study mean dose to organs at risk has been evaluated for the patients of head and neck cancer treated with VMAT.

II. Material and Methods

In the present study 10 patients with carcinoma of head and neck region with age from 28 to 65 years treated with Volumetric Modulated Arc Therapy (VMAT) has been considered. Prescribed dose to tumour was 60 to 70Gy (Gray) depending on the clinical parameters of the disease. Fractionation scheme was 2.0Gy per fraction with daily fractionation and 5 fractions in a week. The details of patient and tumour sites are listed in Table-1. Patients were immobilized with five fixation point thermoplastic, from head to shoulder using all in one (AIO) whole body base plate. Transverse Computed Tomography (CT) images were done from inferior chest to head region in 3mm slice thickness on Brilliance Big Bore CT simulator (Phillips Medical Systems, USA). Target volume and organs at risk located in the vicinity of target and hence likely to be received significant dose were delineated. VMAT plan for all ten patients were generated using Eclipse treatment planning system (Version 10.0), for 6 MV photon beams in Varian Clinac DHX (Varian Medical Systems, Palo Alto, CA) with 120 leaves millennium Multi Leaf Collimator (MLC). Beam arrangements and dose distributions in carcinoma of nasal cavity and right buccal mucosa are shown in Fig.-1 and Fig.-2 respectively. The Progressive Resolution Optimizer (PRO 3) was used to optimize VMAT plans in such a way to minimize dose to organs at risk without compromising tumour coverage. Volume doses were calculated with Anisotropic Analytical Algorithm (AAA version-10.028). Mean dose to organs at risk were evaluated in the present study.

III. Results and Discussion

Mean dose to various organs at risk were listed in Table-2. Considerable variations in mean dose to organs at risk were found from one patient to another. Minimum mean dose to brain was achieved in carcinoma of right buccal mucosa with limited growth, while maximum mean dose was found in carcinoma of right buccal mucosa having growth very extensive and close to the base of skull. In larynx minimum mean dose was found in carcinoma of locally advanced right buccal mucosa without nodal involvement and maximum in carcinoma of base of tongue involving epiglottis and valleculae very close to larynx. Minimum mean dose to eyes and optic nerves were found in carcinoma of locally advanced right buccal mucosa and maximum in carcinoma of nasal cavity which is anatomically near to eyes and optic nerves. In left parotid minimum and maximum mean dose was found in carcinoma of right buccal mucosa with growth limited to primary site and maximum on patient having carcinoma of right buccal mucosa with huge disease involving left cervical lymph node. On the other hand, in the right parotid minimum mean dose was found in carcinoma of left buccal mucosa involving other nearby structures while maximum mean dose in carcinoma of right buccal mucosa in which tumour site was anatomically closure to the right parotid.

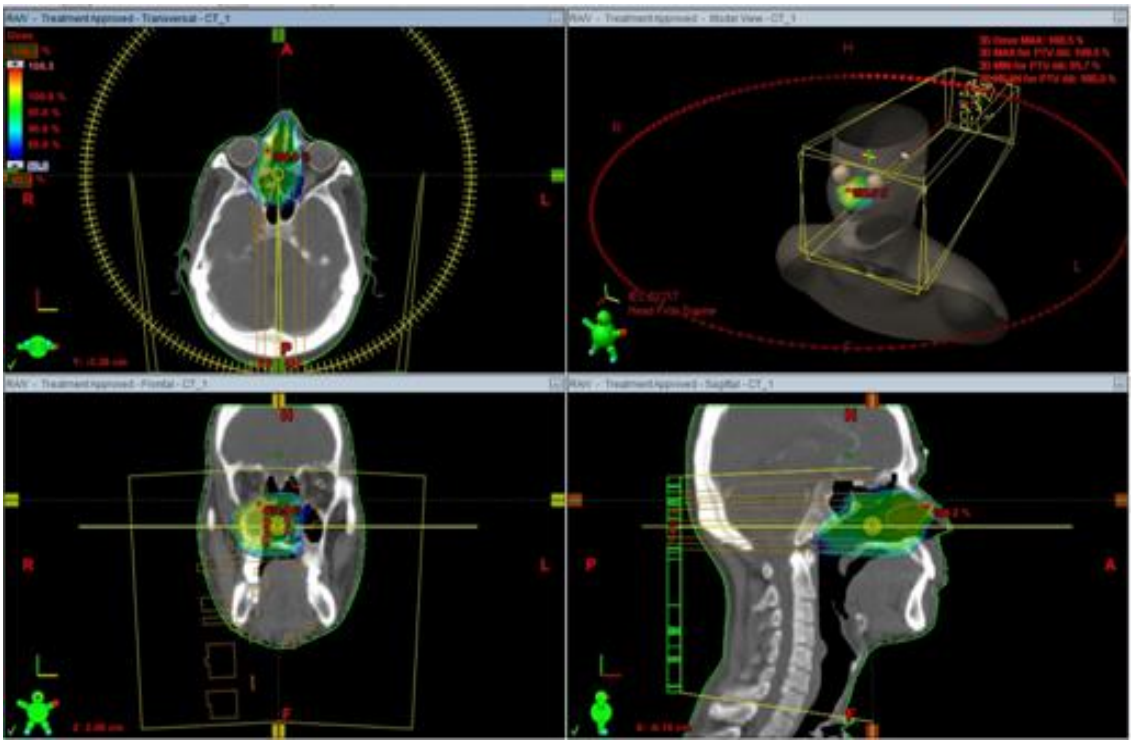

Figure-1: Beam arrangements and dose distributions in carcinoma of nasal cavity.

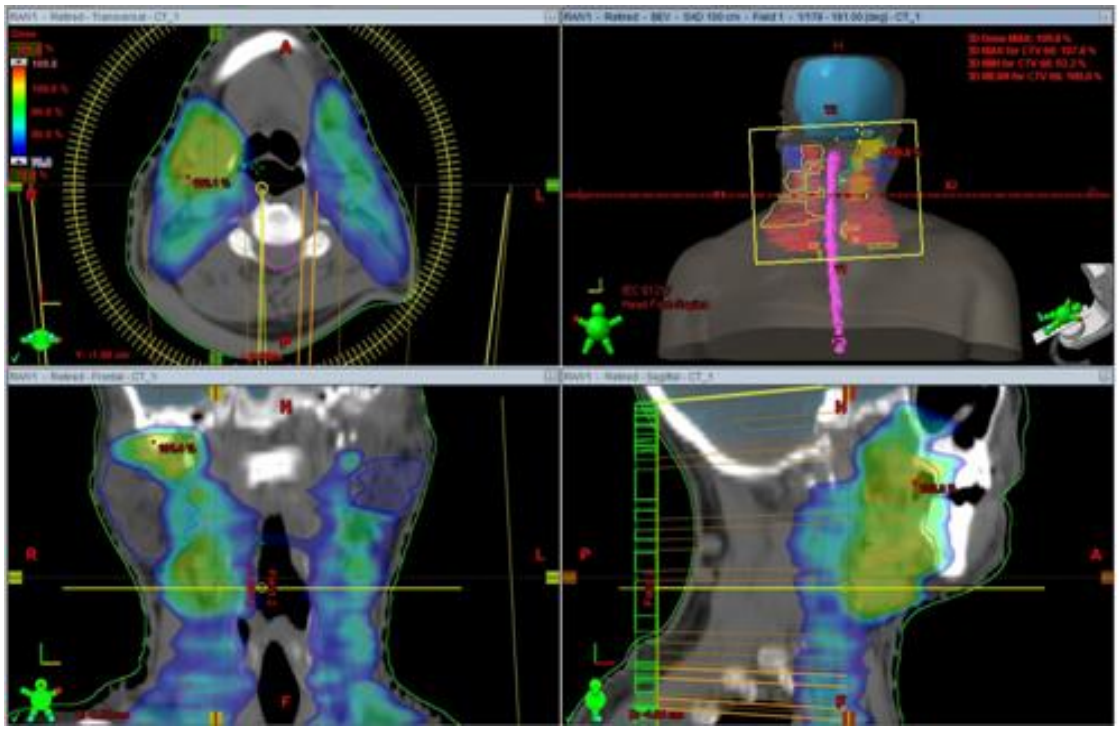

Figure-2: Beam arrangements and dose distributions in carcinoma of right buccal mucosa.

Table-1: Details of patient and site of tumor.

S.N.	Gender	Age (in Years)	Tumor sites	Prescribed dose in Gray (Gy)
1	M	52	Right buccal mucosa	66Gy in 33 fractions
2	M	28	Right buccal mucosa	60Gy in 30 fractions
3	M	38	Right buccal mucosa	66Gy in 33 Fractions
4	M	30	Right buccal mucosa	60Gy in 30 Fractions
5	M	35	Left buccal mucosa	60Gy in 30 Fractions
6	M	65	Alveolus	66Gy in 33 Fractions
7	M	28	Nasal Cavity	66Gy in 33 Fractions
8	F	63	Alveolus involving tongue	66Gy in 33 Fractions
9	M	50	Tongue	60Gy in 30Fractions
10	M	60	Base of Tongue	70Gy in 35 Fractions

Table-2: Mean dose to critical organs

S.N.	Organ at risk	Mean dose (in Gy)	
		Minimum	Maximum
1	Brain	3.0	7.3
2	Larynx	19.8	55.2
3	Oropharynx	12.8	47.6
4	Left Eye	5.2	9.7
5	Right Eye	9.8	10.9
6	Left Optic nerve	3.8	8.6
7	Right Optic nerve	5.7	10.3
8	Left Parotid	5.6	29.4
9	Right Parotid	13.5	45.3

IV. Conclusion

Minimum mean dose to organs at risk are primarily depends upon the location of critical organs with respect to target volume. Use of VMAT significantly reduces dose to the critical organs without compromising dose to the tumour in the treatment of head and neck cancer. It result better loco-regional control with minimal normal tissue complication and hence comparatively better quality of life to the patients with head and neck cancer.

Acknowledgements

We sincerely want to thank Dr. A. K. Chandrakar, Dean, Pt. J.N.M. Medical College, Raipur, for his continuous encouragement, guidance and support in the present study.

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