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Research Article

EVALUATION OF INSTITUTIONAL PLANNING TARGET VOLUME MARGIN FOR HEAD AND NECK CANCERS TREATED ON LINEAR ACCELERATOR-A PROSPECTIVE STUDY

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Abstract

Introduction: Head and neck cancers represent a significant global health burden, accounting for a substantial proportion of cancer-related morbidity and mortality worldwide. These malignancies arise from diverse anatomical subsites, including the oral cavity, oropharynx, hypopharynx, and larynx, and are often diagnosed at locally advanced stages. Radiotherapy, either alone or in combination with surgery and chemotherapy, plays a pivotal role in their management.

Materials and methods: This study conducted in Department of Radiation Oncology, Great Eastern Medical School and Hospital, Srikakulam, AP for a period of 12 months from May 2022 to April 2023 in 122 patients of head and neck cancers treating under IMRT in Novalis TX linear accelerator with thermoplastic immobilization device. All head and neck cancer patients, of age- 18-70 yrs, with Eastern Cooperative oncology group (ECOG) performance status between 0-2, treated in supine position with four clamp immobilization device. Patients with recurrent tumor are also included. Tumors in which neck is not a part of treating area and immobilization device other than four clamp were excluded from the study.

Results: The study has been conducted in the Department of Radiation Oncology, Great Eastern Medical School and Hospital, Srikakulam, AP. A total of 122 patients, who satisfied the eligibility criteria, were studied. Zero patients defaulted/died during treatment. 78 % of population are males and 22 % of population are females. 54% of the population consumed smokeless tobacco in many forms like Paan, ghutka, jarda and betel quid with tobacco and had smoking history. 57 % of the population gave history of alcohol consumption. 36% of the population received concurrent chemotherapy with an average of 5 cycles of weekly Cisplatin at a dose of 40 mg/m2 or at a dose of 100mg/m2 for every 3 weeks.

Conclusion: This study emphasizes on the importance of good immobilization and on maintenance of nutritional status that can have an impact on setup errors and treatment outcome. It also highlights the need for institutional study in deriving a PTV margin for their own treatment setup while treating different primary sites. This should be accompanied by complete analysis of all the possible reasons that contribute to the error magnitude and the steps that need to be taken to reduce them in their treatment setup.

Key words: Head and neck cancers, Radiotherapy, immobilization, chemotherapy.

INTRODUCTION

Head and neck cancers represent a significant global health burden, accounting for a substantial proportion of cancer-related morbidity and mortality worldwide. These malignancies arise from diverse anatomical subsites, including the oral cavity, oropharynx, hypopharynx, and larynx, and are often diagnosed at locally advanced stages. Radiotherapy, either alone or in combination with surgery and chemotherapy, plays a pivotal role in their management.[1]

With the advent of advanced radiotherapy techniques using linear accelerators, such as three-dimensional conformal radiotherapy (3D-CRT), intensity-modulated radiotherapy (IMRT), and image-guided radiotherapy (IGRT), there has been a paradigm shift toward more precise dose delivery. These techniques allow better sparing of surrounding normal tissues while maintaining adequate tumor coverage. However, accurate target delineation remains a critical challenge in achieving optimal therapeutic outcomes.[2]

In radiotherapy planning, the Clinical Target Volume (CTV) is expanded to form the Planning Target Volume (PTV) to account for uncertainties such as patient setup errors, organ motion, and variations in treatment delivery. The margin added to generate the PTV is crucial: insufficient margins may lead to geographic miss and tumor recurrence, while excessive margins can increase radiation exposure to adjacent healthy tissues, leading to higher toxicity.[3]

The purpose of the PTV margin is to compensate for various uncertainties related to treatment delivery, if not corrected, it may cause differences between the intended and actual delivered dose distribution to the CTV. This CTV to PTV margin is much more important for intensity modulated radiation therapy (IMRT) plans as they usually have high dose gradients between tumor volume and adjacent normal tissue.[4]

This study is planned at our Radiation Oncology Department which is equipped with kV x ray portal imaging (PI) to detect daily translational set up errors in 3 dimensions (X, Y, Z). The final aim of this study is to generate appropriate PTV margins for the head and neck tumors treated with IMRT technique in our department from the daily shifts detected using portal imaging. The findings in the study guide us to generate planning target volume more accurate which can reduce the irradiated area in patient's body and decrease treatment related toxicities. At the same time, under-dose or geographical miss of the tumor can be avoided.[5]

MATERIALS AND METHODS

This study conducted in Department of Radiation Oncology, Great Eastern Medical School and Hospital, Srikakulam, AP for a period of 12 months from May 2022 to April 2023 in 122 patients of head and neck cancers treating under IMRT in Novalis TX linear accelerator with thermoplastic immobilization device.

Inclusion Criteria: All head and neck cancer patients, of age 18-70 yrs, with Eastern Cooperative oncology group (ECOG) performance status between 0-2, treated in supine position with four clamp immobilization device. Patients with recurrent tumor are also included.

Exclusion Criteria: Tumors in which neck is not a part of treating area and immobilization device other than four clamp.

Immobilization - Patients were immobilized in supine position with hands by the side of body on AIO board with customized thermoplastic mask after placing appropriate neck rest. Head was extended depending on the location of tumor.

Simulation - By using 64 slice Philips CT simulator, 2-3 mm CT axial cuts of head, neck and thorax of the patient are acquired with immobilization device and fiducials. Radiation fields were simulated and optical field projection was marked on the thermoplastic mould for subsequent positioning and treatment. Fiducials are used to mark virtual isocentre and it was also useful to reproduce the simulated position while treating.

Treatment Planning Process - The CT images are exported to Eclipse 13.6 planning system in DICOM format. Fusion of CT simulator images and Pre-op/diagnostic images were performed. The Radiation Oncologist delineates critical organs and Clinical Target Volume (CTV) on the fused images. After this, isotropic margin of 5-7 mm applied around CTV, yielding Planning target volume (PTV).

Inverse planning technique featured by the treatment planning software Eclipse 13.6 (Varian Medical System, Palo Alto, US) was applied to elaborate the IMRT plan. IMRT plan is generated by medical physicist, evaluated and approved by radiation oncologist. The DRR images were acquired from the CT simulation images in both anterio-posterior and lateral directions.

Imaging and Verification - All patients were treated by Linear accelerator machine with source to axis distance (SAD) 100 cm using 6MV energy. Patients were positioned in accordance with the treatment beam using treatment room lasers and marks on the immobilization device.

Statistical Analysis

In this study, 61 patients are enrolled and analyzed. Mean, Standard deviation is calculated for X, Y, Z axis. Systematic and Random error are derived and Planning Target Volume margin is generated by using Van Herk's formulae.

All the qualitative variables like gender, diagnosis, histology of head and neck tumor are represented as frequencies and percentages. Quantitative parameters like age, PTV margin in X, Y, Z axis is represented with descriptive statistics like mean, standard deviation. All the data entered and maintained in MS.Excel and

analyzed by using SPSS23.0v. For calculation of weekly errors and their comparison, p value is calculated by using Post Hoc tests with ANOVA at 95 % confidence interval. p value is considered significant when p is less than or equal to 0.05.

RESULTS

The study has been conducted in the Department of Radiation Oncology, Great Eastern Medical School and Hospital, Srikakulam, AP. A total of 122 patients, who satisfied the eligibility criteria, were studied. Zero patients defaulted/died during treatment. 78 % of population are males and 22 % of population are females. 54% of the population consumed smokeless tobacco in many forms like Paan, ghutka, jarda and betel quid with tobacco and had smoking history. 57 % of the population gave history of alcohol consumption. 36% of the population received concurrent chemotherapy with an average of 5 cycles of weekly Cisplatin at a dose of 40 mg/m2 or at a dose of 100mg/m2 for every 3 weeks.

Gender	Frequency	Percentage
Male	96	78
Female	26	22
Total	122	100
Smoking history	Frequency	Percentage
Yes	66	54
No	56	46
Alcohol history	Frequency	Percentage
Yes	70	57
No	52	43
Concurrent Chemotherapy	Frequency	Percentage
Yes	44	36
No	78	64
Total	122	100

Table 1: Demographic distribution in present study

HPE	Frequency	Percentage
Well differentiated SCC	46	40
Moderately differentiated SCC	48	41
Poorly differentiated SCC	6	5
Spindle cell variant, SCC	2	2
Not graded	14	12
Adenoid cystic carcinoma	6	5

Table 2: Descriptive statistics of the Histopathological types

Intent of Radiotherapy	Frequency	Percentage
Adjuvant	78	64
Radical	44	36
Total	122	100
Location of Tumor	Frequency	Percentage
Oral Cavity	62	51
larynx	30	25
Oropharynx	10	8
Hypopharynx	10	8
Paranasal Sinuses	6	5
Salivary gland	4	3

Table 3: Descriptive statistics showing Intent of radiotherapy

DISCUSSION

A total of 122 patients of head and neck cancers who satisfied the eligibility criteria were analyzed in this study. This report attempts to evaluate the set-up accuracy in patients receiving radiotherapy for head and neck cancers with IMRT at radiotherapy unit of GEMS by using OBI and EPID systems. As the main aim of delivering radiotherapy is to give adequate tumoricidal dose and spare nearby normal tissues, maintaining accuracy plays a crucial role.[6]

In general, attempts to reduce treatment related uncertainties begin from accurate delineation of the tumor which is the Gross Tumor Volume (GTV) and giving an appropriate margin, i.e., CTV (clinical target volume) around the GTV to cover the microscopic extent of the disease by predicting the routes of loco regional spread based on the primary tumor site. In order to ensure not to miss the target volume, a PTV margin (Planning target volume) is given around the CTV to account for the setup errors. Every attempt has to be made to look into the possible causes of the errors and measures have to been taken to correct them.[7]

EPID is a primary tool for quality assurance in radiation delivery. Current commercially available EPIDs use flat panel display technology, providing faster acquisition and superior image quality. In combination with a modern digital accelerator fitted with multileaf collimator, field set-up and image acquisition can be done remotely and displayed in seconds, obviating the need to re-enter the treatment room each time.[8,9]

This study attempted to observe the systematic and random errors while treating head and neck cancers with EBRT on Linear accelerator so as to derive an institutional PTV margin which is appropriate for this treatment setup. Patients who satisfied the inclusion criteria were immobilized with thermoplastic cast after positioning them in supine position. CT simulation was done and 2-3 mm slices were obtained from vertex to mid chest with fiducials markers placed on the thermoplastic cast.[10]

CONCLUSION

This study emphasizes on the importance of good immobilization and on maintenance of

nutritional status that can have an impact on setup errors and treatment outcome. It also highlights the need for institutional study in deriving a PTV margin for their own treatment setup while treating different primary sites. This should be accompanied by complete analysis of all the possible reasons that contribute to the error magnitude and the steps that need to be taken to reduce them in their treatment setup.

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