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Global Journal of Cancer Therapy — Open Access Journal

ISSN: 2581-5407 DOI: https://dx.doi.org/10.17352/gjct

Research Article

Assessment of the role of multimodality imaging for treatment volume definition of intracranial ependymal tumors: An original article

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Received: 28 June, 2021
Accepted: 05 July, 2021
Published: 06 July, 2021

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Keywords: Intracranial ependymal tumor; Irradiation; Target definition

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Abstract

Objective: Radiotherapy (RT) can be used for primary treatment, adjuvant therapy, or for salvage of recurrences of intracranial ependymal tumors. In recent years, there is a rising trend towards reducing the adverse effects of RT by incorporation of modernized techniques. Accurate and precise RT treatment volume is essential for optimization of treatment results. Herein, we evaluated irradiation target designation of intracranial ependymal tumors.

Materials and methods: In this study, irradiation target designation was assessed for intracranial ependymal tumors. RT target volume definition was evaluated with comparative analysis for patients receiving irradiation for intracranial ependymal tumors.

Results: Optimal target coverage and minimal exposure of normal tissues was prioritized in RT treatment planning. Ground truth target volume determination was done with meticulous assessment of physicians. As the primary result, it was found that the ground truth target voume was identical with target determination with Computed Tomography (CT)-Magnetic Resonance Imaging (MRI) fusion based planning.

Conclusion: Incorporation of MRI in target definition process should be suggested for improving accuracy and precision of target and treatment volume definition for successful radiotherapeutic management of intracranial ependymal tumors despite the need for further supporting evidence.

Introduction

Ependymomas refer to glial tumors arising from ependymal tissue of Central Nervous System (CNS). These tumors may be derived from the radial glial cells in subventricular zone . Ependymomas comprise approximately one fourth of primary tumors originating in spinal cord, and less than 10% of CNS tumors. There may be an increased incidence of intramedullary spinal cord ependymoma in cases of neurofibromatosis type 2. While the location is typically intracranial in children, adult ependymomas mostly have spinal location. Patient presentation and symptomatology depend on lesion localization. Fourth ventricle is a very common location for intracranial ependymomas, and extension into subarachnoid space may occur. Symptoms may include headache, nausea and vomiting, visual impairment, drowsiness, Babinski sign, constipation, and gait disturbances.

Surgical intervention is required for establishing the diagnosis of ependymoma. Imaging modalities may also be utilized. Computed Tomography (CT) typically shows a hyperdense lesion with homogeneous enhancement, and cysts and calcifications may be seen. Tumor at fourth ventricle having calcifications may suggest a diagnosis of ependymoma, however, histopathological verification is required. Magnetic Resonance Imaging (MRI) typically demonstrates a hypointense

Citation: Dincoglan F, Sager O, Demiral S, Beyzadeoglu M (2021) Assessment of the role of multimodality imaging for treatment volume definition of intracranial ependymal tumors: An original article. Glob J Cancer Ther 7(1): 043-045. DOI: https://dx.doi.org/10.17352/2581-5407.000041

lesion on T1 weighted sequences and hyperintensity on T2 weighted sequences and proton density images with frequently prominent contrast enhancement. Restricted diffusion may be observed on diffusion weighted MRI sequences. Extention of ependymomas into foramen Luschka is not uncommon. Also, the obstruction of supratentorial ventricular system or the fourth ventricle by the lesion may cause hydrocephalus with increased intracranial pressure.

Surgery may be used for management of intracranial ependymal tumors, however, other therapeutic modalities including Radiation Therapy (RT) and chemotherapy may be utilized [1-15]. RT may have a role as part of primary treatment, as adjuvant therapy, or for management of recurrences [3-15]. In recent years, there is a rising trend towards reducing the adverse effects of RT by incorporation of modernized techniques. Accurate and precise RT treatment volume is essential for optimization of treatment results. Herein, we evaluated RT target definition for intracranial ependymal tumors.

Materials and methods

In this study, irradiation target volume definition was assessed for 15 patients with intracranial ependymal tumors. Patient characteristics are summarized in Table 1.

A total of 15 patients were included in the study. Nine patients (60%) were male and 6 patients (40%) were female. Median age was 21 years. All patients had intracranial ependymal tumors with histopathological confirmation. RT target volume definition by incorporation of MRI or by CT-simulation images was evaluated for irradiation of intracranial ependymal tumors. Ground truth target volume was collaboratively defined. All patients were thoroughly assessed on an individual basis with consideration of lesion size, location, symptomatology, contemplated results regarding radiotherapeutic management. CT-simulator was used for treatment simulation at our tertiary cancer center. Images have been acquired, and afterwards transferred for delineation of target and surrounding critical structures. Target designation by CT only and with utilization of CT-MR fusion was assessed.

Results

Contemporary RT treatment planning systems at our tertiary referral institution were used. Optimal target coverage and minimal exposure of normal tissues was considered as priority. Ground truth target volume was determined after meticulous assessment of physicians. Target determination was assessed. An overlap of 100% has been detected between CT-MR fusion based target definition and ground truth target volume determination by the board certified radiation oncologists following meticulous assessment, colleague peer review, collaboration, and ultimate consensus. As the primary result, it was found that the ground truth target voume was identical with target determination with CT-MR fusion based imaging. Table 2 demonstrates treatment characteristics and comparative analysis of target determination with CT-MR fusion based imaging and ground truth target voume definition.

Table 1: Patient characteristics.

Patient characteristic	Number	%
Number of patients Male Female	15 9 6	100 60 40
Diagnosis Intracranial ependymal tumor	15	100
Median age (range)	21 years	

Table 2: Treatment characteristics and comparative analysis of target determination with CT-MR fusion based imaging and ground truth target voume definition.

Indication for irradiation Intracranial ependymal tumor	15 patients (100%)
Treatment Machine Linear Accelerator (LINAC)	15 patients (100%)
Comparative analysis of target determination with CT-MR fusion based imaging and ground truth target voume definition	Overlap between target determination with CT-MR fusion based imaging and ground truth target volume definition 100%

Discussion

Incorporation of contemporary technologies may reduce adverse effects of RT in the millennium era. Using effective doses of radiation with optimal sparing of critical structures may improve treatment outcomes for patients suffering from intracranial ependymoma. In this regard, accurate treatment volume determination is an indispensable aspect of contemporary irradiation strategies. There has been significant progress with excellent improvements regarding radiation oncology practice by introduction of modernized treatment equipment, contemporary and adaptive irradiation strategies [16-20]. With regard to radiotherapeutic management of intracranial ependymomas, accumulating data suggest promising treatment results [3-15]. With this in mind, precision in target designation becomes essential for optimized irradiation protocols with the incorporation of recent RT delivery techniques and modalities. More focused irradiation of well defined targets has been possible by use of radiosurgical techniques with stereotactic immobilization and image guidance, however, extreme hypofractionation with sophisticated technologies necessiates improved precision and accuracy in treatment volume determination to avoid geographic misses, treatment failures, and radiation induced adverse effects. While definition of huge treatment volumes could result in increased doses to surrounding normal tissues with resultant toxicity, determination of inadequate treatment volumes can result in treatment failures. In this regard, there is an obvious need for optimization of target volume determination. In the literature, there is accumulating of evidence in support of CT-MR fusion based target volume determination for several indications [21-25]. However, there is paucity of data regarding the utility of multimodality imaging for RT planning of intracranial ependymal tumors. Within this context, our study may add to accumulating data on multimodality imaging based treatment volume determination for radiotherapeutic management of intracranial ependymal tumors.

In conclusion, precision and accuracy in target and treatment volume definition of intracranial ependymomas

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may be considered as an integral component of optimal radiotherapeutic management. In this regard, incorporation of MRI in target designation process should be suggested for improving accuracy and precision of target and treatment volume definition for successful radiotherapeutic management of intracranial ependymal tumors.

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