



Assessment of Treatment Volume Definition for Irradiation of Spinal Ependymomas: an Original Article

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Abstract

Background: Ependymomas may arise from the spinal cord or the cranial ventricular system and constitute a heterogeneous group of central nervous system (CNS) tumors. Spinal ependymomas are mostly low grade tumors with an indolent disease course. However, symptomatic presentation may occur in some patients. Irradiation may play an integral role in management particularly as a complementary treatment modality. Definition of treatment volumes for irradiation of spinal ependymomas have been poorly addressed in the literature. In this context, we assessed the incorporation of multimodality imaging with magnetic resonance imaging (MRI) in treatment volume definition for irradiation of spinal ependymomas in this original research article.

Materials and Methods: Irradiation target volume definition based on multimodality imaging with incorporation of MRI or by use of the Computed Tomography (CT)-simulation images only was comparatively evaluated for patients with spinal ependymoma.

Results and Conclusion: Thorough evaluation was performed for lesion size, location, patient symptomatology and preferences along with expected treatment outcomes on an individual basis. Comparative assessment of irradiation treatment volume determination by CT-only imaging and by CT-MR fusion based imaging revealed that ground truth target volume outlined by the board-certified radiation oncologists was identical to target definition by use of CT-MR fusion based imaging. In conclusion, treatment volume determination composes an important part of irradiation for spinal ependymomas. Incorporation of MRI into the treatment volume definition process for precise radiation treatment planning for spinal ependymomas may be utilized to achieve improved outcomes, nevertheless, further study is required to shed light on this critical issue.

Keywords: Spinal Ependymoma, Irradiation, Magnetic Resonance Imaging (MRI)

1. INTRODUCTION

Primary spinal cord tumors are mostly ependymomas and astrocytomas which may be treated primarily by surgery as the traditional treatment modality and irradiation as an adjunctive, salvage or primary treatment in selected patients. [1-11] Ependymomas may arise from the spinal cord or the cranial ventricular system and constitute a heterogeneous group of central nervous system (CNS) tumors which may be observed in both the pediatric and adult population. Spinal ependymomas are mostly low grade tumors with an indolent disease course. World Health Organization (WHO) classification includes 3 grades of ependymomas with regard to degree of malignancy detected by microscopy. [12] WHO grade I lesions include myxopapillary

ependymoma and subependymoma. [12] WHO grade II lesions include classic, papillary, cellular, tanycytic, and clear cell subtypes with similar biological behaviour and without anaplastic characteristics. [12] WHO grade III lesions are anaplastic ependymomas with most malignant behaviour. [12] Resectability, locations, and recurrence tendencies show diversities between WHO grade I, II, and III ependymomas. Majority of lesions occurring in the spinal cord include the WHO grade II classic ependymoma and most frequent location is the cervical or thoracic region.

Magnetic resonance imaging (MRI) is the principal imaging modality for ependymomas. [5,13] Computed tomography (CT), which is the main procedure utilized for radiation treatment planning (RTP) purposes may aid in detection of

calcifications. Expansion of the cord is a critical finding for identification of intramedullary tumors. [5] Ependymomas are typically contrast enhancing lesions visualized as hypointense lesions on T1 weighted MRI sequences and hyperintense lesions on T2 weighted MRI sequences relative to the spinal cord. [5] Heterogeneous signals may result from areas of calcification, necrosis, bleeding, or cystic changes. [5] Myxopapillary ependymomas are mostly found in the conus medullaris region as well defined tumors with uniform contrast enhancement. [5] Contrast enhancement may be variable for anaplastic ependymomas which may have a tendency for infiltration of surrounding tissues, and complete neuroaxis imaging may assist in detection of metastases if present for these high grade tumors. [5] Despite differences in imaging characteristics of ependymomas of different subtypes, imaging based assessments may fail to exactly differentiate between grades for some patients. [5]

Radiation therapy (RT) in the forms of conventionally fractionated RT (CFRT) or radiosurgery as Stereotactic Radiosurgery (SRS), Hypofractionated Stereotactic Radiotherapy (HFSRT), and Stereotactic Body Radiotherapy (SBRT) may be utilized for contemporary management of many CNS disorders as well as several other tumors throughout the human body with encouraging outcomes. [14, 36]

In the context of spinal ependymomas, irradiation may play an integral role in management particularly as a complementary treatment modality. [5, 9, 11] Definition of treatment volumes for irradiation of spinal ependymomas have been poorly addressed in the literature. In this context, we assessed the incorporation of multimodality imaging with MRI in treatment volume definition for irradiation of spinal ependymomas in this original research article.

2. MATERIALS AND METHODS

Irradiation target volume definition based on multimodality imaging with incorporation of MRI or by use of the CT-simulation images only was comparatively evaluated for patients with spinal ependymoma in this study. Ground truth target volume serving as the reference for actual treatment and comparison purposes was defined by the board-certified radiation oncologists after colleague peer review, collaboration, and ultimate consensus. Informed consents were acquired before treatment.

Thorough evaluation was performed for lesion size, location, patient symptomatology and preferences along with expected treatment outcomes on an individual basis.

Patient simulation for RTP was performed at CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) available in our tertiary cancer center. Planning CT images were taken and then transferred to the delineation workstation (SimMD, GE, UK) for contouring of treatment volumes and critical structures. Either CT-simulation images only or fused CT and T1 gadolinium-enhanced MR images were utilized for target volume definition for irradiation. Target determination with CT only and by incorporation of CT-MR fusion was comparatively evaluated. Determination of the ground truth target volume was performed by the board-certified team of radiation oncologists after detailed assessment, collaboration, colleague peer review and ultimate consensus for use in actual treatment as well as for comparison purposes. Treatment delivery was performed by use of the Synergy (Elekta, UK) linear accelerator (LINAC) available at our institution.

3. RESULTS

RTP was performed by the available treatment planning system in our institution. Priority was given to achieve optimal target coverage with minimization of normal tissue exposure. Synergy (Elekta, UK) LINAC was used for delivery of treatment.

Irradiation target volume determination by CT-only imaging and by CT-MR fusion based imaging was comparatively assessed in the current study. Ground truth target volume outlined by the board-certified radiation oncologists after detailed evaluation, collaboration, colleague peer review and ultimate consensus was identical to target definition by use of CT-MR fusion based imaging.

4. DISCUSSION

Spinal ependymomas are usually low grade tumors following an indolent disease course. Patients may have nonspecific symptoms for a long time before diagnosis. Frequently observed symptoms may include gait disturbances, spasticity in lower limbs, pain, sensory impairments and paresthesias. Tumors located at the lumbar region may cause radicular pain and incontinence which may deteriorate quality of life.

Surgery and irradiation may be utilized for management of spinal ependymomas. [1-11] While surgery serves as the principal and traditional treatment modality, irradiation may be used as an adjunct therapy or in the setting of recurrences. Selected patients deemed inoperable due to several comorbidities or other conditions may be considered for irradiation in an attempt to provide tumor control and alleviation of symptoms.

Recent years have witnessed huge growth in irradiation capacity of several cancer centers for a wide variety of benign and malign conditions. There have been important advances in the discipline of radiation oncology such as introduction of adaptive irradiation strategies and contemporary treatment delivery techniques including Image Guided Radiation Therapy (IGRT), Adaptive Radiation Therapy (ART), Intensity Modulated Radiation Therapy (IMRT), Breathing Adapted Radiation Therapy (BART), and stereotactic irradiation with SRS, HFSRT, and SBRT. [37, 43]

Definition of irradiation treatment volumes composes an important aspect of radiotherapeutic management. Avoidance of geographical misses and excessive treatment related toxicity are pertinent irradiation goals. While definition of larger treatment volumes may translate into severe irradiation related toxicity, determination of smaller than actual treatment volumes may lead to geographical misses with resultant disease progression. Incorporation of multimodality imaging may be used for improving the accuracy and precision of target localization, and complementary use of fused CT and MR images may provide improved treatment volume definition for irradiation. There is paucity of data in the literature focusing on the usefulness of multimodality imaging for RTP of spinal ependymomas. In this context, our study may add to the literature by suggesting routinized incorporation of MRI into the RTP process to achieve improved outcomes for patients with spinal ependymomas. Indeed, improvement in treatment volume definition has also been supported by a few other studies in the literature. [44, 57]

5. CONCLUSION

In conclusion, treatment volume determination composes an important part of irradiation for spinal ependymomas. Incorporation of MRI into the treatment volume definition process for precise radiation treatment planning for spinal

ependymomas may be utilized to achieve improved outcomes, nevertheless, further study is required to shed light on this critical issue.

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