Target Volume Determination for Precise Radiation Therapy (RT) of Central Neurocytoma: An Original Article

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ABSTRACT

Objective: Central Neurocytoma (CN) is a rarely seen intracranial neoplasm. A frequent manifestation of CN includes symptomatology related to increased intracranial pressure as a result of obstructive hydrocephalus. Radiation therapy (RT) may be utilized for CN to improve tumor control in selected patients. Precision in determination of the target volume is an essential component of contemporary RT. In this study, we assess the incorporation of magnetic resonance imaging (MRI) for radiation treatment planning for CNs.

Materials and Methods: Evaluation of RT target volume determination with and without incorporation of MRI has been performed. Ground truth target volume used for actual treatment and comparison purposes has been defined by the board-certified radiation oncologists after comprehensive assessment, thorough collaboration, colleague peer-review, and ultimate consensus.

Results: Target volume determination by CT-only imaging and by CT-MR fusion based imaging has been comparatively assessed for RT of CN in this study. Ground truth target volume defined by the board-certified radiation oncologists after thorough evaluation, collaboration, colleague peer review and ultimate consensus has been found to be identical to target determination by use of CT-MR fusion based imaging.

Conclusion: Despite substantial advances in neurosurgical techniques, complete tumor removal may not be feasible for deeply seated lesions in selected patients with CNs. RT may play an essential role for multidisciplinary CN management. Incorporation of multimodality imaging with MRI into the radiation treatment planning process may improve the accuracy and precision in target definition for CNs, however, there is need for further studies.

Keywords: central neurocytoma (CN), radiation therapy (RT), magnetic resonance imaging (MRI)

INTRODUCTION

Central Neurocytoma (CN) is a rarely seen intracranial neoplasm comprising about 0.1% to 0.5% of intracranial tumors with the peak incidence typically between the ages of 20 to 31 years [1-3]. Most common lesion location includes the anterior half of lateral ventricles with attachment to septum pellucidum and locations for extra ventricular neurocytoma include the frontal lobe, cerebellum, temporal lobe, and others [1-3]. Lesions arising from the third or fourth ventricles are quite uncommon [4-7].

A frequent manifestation of CN includes symptomatology related to increased intracranial pressure as a result of obstructive hydrocephalus. Differentiation of CNs from other brain tumors based on imaging features may be difficult which underscores the incorporation of histological markers including synaptophysin to aid in diagnosis [3]. Primary objective of management includes total tumor removal by means of gross total resection, which offers favorable prognosis with satisfactory rates of local control and survival [2,3]. However, complete surgical resection may not be feasible for management of deeply seated lesions regarding the excessive risks of surgery in selected patients and radiation therapy (RT) may be utilized for these patients to achieve improved tumor control. Utility of chemotherapy for management of CN merits further investigation, however, chemotherapy may be used in the recurrent and salvage settings as adjunct therapy to improve treatment outcomes [8]. Nevertheless, optimal management of CNs may be performed with incorporation of multimodal treatments [9].

Given that CNs may have a propensity for recurrence even after initial management with surgery, particularly when complete tumor removal is not feasible, RT in the forms of conventionally fractionated RT or radio surgery may be utilized[10-22]. Contemporary RT
technologies and radio surgery in the forms of Stereotactic Radio surgery (SRS), Stereotactic Body Radiotherapy (SBRT) and Hypofractionated Stereotactic Radiation Therapy (HFSRT) may be used for focused irradiation of several CNS disorders as well as tumors located throughout the human body with favorable therapeutic results [23-43].

Precision in determination of the target volume is an essential part of contemporary RT and particularly for radiosurgical practice given the smaller target volumes receiving significantly higher doses per fraction. Traditionally, treatment planning for radiation treatment has been based on CT-simulation images of patients acquired at the treatment position. In this study, we assess the incorporation of MRI for radiation treatment planning for CNs.

MATERIALS AND METHODS
In this study, evaluation of RT target volume determination with and without incorporation of MRI has been performed. Ground truth target volume serving as the reference has been outlined by the board-certified radiation oncologists after detailed assessment, thorough collaboration and ultimate consensus. Informed consents have been acquired before treatment, and management with RT has been decided by the multidisciplinary collaboration of experts from neuro radiology, neurosurgery, and radiation oncology. Comprehensive assessment has been done considering lesion size, location, patient symptomatology and preferences. Patient immobilization has been performed by using a thermoplastic mask. After immobilization, planning CT images have been acquired at the CT-simulator (GE Light speed RT, GE Healthcare, Chalfont St. Giles, UK) available at our institution including the region extending from the vertex to the 2 cm below the cervical spine. Acquired planning CT images were sent to the contouring workstation (Sim MD, GE, UK) for delineation of treatment volumes along with surrounding normal tissues. Target volume determination for RT has been done based on the CT-simulation images only or fused CT and MR images. A comparative evaluation of target determination with CT only and by incorporation of CT-MR fusion has been done. Determination of ground truth target volume to be utilized for actual treatment and comparison purposes has been done by the board certified radiation oncologists after comprehensive evaluation, colleague peer review, collaboration and ultimate consensus.

RESULTS
Definition of CN target volume by use of CT-only imaging and by incorporation of CT-MR fusion based imaging has been comparatively assessed in this study for RT using the linear accelerator (LINAC). Ground truth target volume determined by the board-certified physicians after comprehensive assessment, collaboration, colleague peer review and ultimate consensus has been detected to be identical to target determination by use of CT-MR fusion based imaging.

Radiation treatment planning has been performed by Precise (Elekta, UK) treatment planning system. Optimal target coverage and normal tissue sparing has been provided by incorporation of contemporary techniques. Synergy (Elekta, UK) LINAC available at our tertiary cancer center has been utilized for treatment delivery.

Figure 1 shows axial CT image of a patient with CN, and figure 2 shows the corresponding axial MR image of the same patient with CN.

![Figure 1. Axial CT image of a patient with CN](image-url)
DISCUSSION

MRI is the imaging modality of choice for assessment of several intracranial pathologies. In addition to its utility for diagnosis of brain tumors, evaluation of treatment response, differentiation of recurrence and side effects of RT, detection and characterization of brain lesions with incorporation of functional imaging techniques, another important contribution of MRI is in target definition for precise radiation treatment planning.

Recent years have witnessed substantial improvements in the discipline of radiation oncology such as contemporary treatment strategies 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 [44-50].

Multimodality imaging may be utilized for improving the accuracy and precision of target delineation. Incorporation of combined use of fused CT and MR images may be utilized for supplementing each other to improve precision in delineation of target volumes for state of the art RT techniques. Usefulness of multimodality imaging for radiation treatment planning of CNs has been poorly addressed in the literature. In this context, our study may add to the existing body of literature by reporting improved target determination by incorporation of MRI in radiation treatment planning of CNs. Several other studies have also suggested a role for multimodality imaging in target volume definition for precision RT [51-62].

In conclusion, incorporation of MRI into radiation treatment planning of CNs may improve precision and accuracy in target definition, however, there is need for further studies.

REFERENCES

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