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Research article

Assessment of posterior fossa target definition by multimodality imaging for patients with medulloblastoma

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Abstract

Objective: Medulloblastoma is a frequent childhood brain tumor which may occur in the vermis, cerebellum and posterior fossa. Affected patients may suffer from a variety of symptoms due to elevated intracranial pressure and may present with headaches, nausea and vomiting, cranial deficits, truncal ataxia, titubation of the head, alterations in mental status and gait disturbances. Accuracy in target and treatment volume definition has been thoroughly studied to achieve better outcomes. Herein, we assessed posterior fossa target definition by multimodality imaging patients with medulloblastoma.

Materials and methods: In this study, posterior fossa target definition with multimodality imaging by incorporation of Magnetic Resonance Imaging (MRI) or by Computed Tomography (CT)-simulation images only was evaluated comparatively for patients with medulloblastoma. Board certified radiation oncologists have outlined the ground truth target volume as the reference for actual treatment and for comparison purposes after thorough assessment, collaboration, colleague peer review, and ultimate consensus.

Results: RT planning was performed by use of the available treatment planning systems at our tertiary referral institution with prioritization of target coverage and normal tissue sparing to improve the therapeutic ratio. Decision making for individualized patient management was performed by multidisciplinary evaluation of experts from neurosurgery, radiology, pediatric oncology, medical oncology, and radiation oncology. Synergy (Elekta, UK) LINAC was used for RT administration. Ground truth target volume was found to be identical with target volume definition with CT-MR fusion based imaging as the result of this study.

Conclusion: Multimodality imaging should be strongly considered for improved posterior fossa RT target definition of medulloblastoma. Apparently, further studies may be needed to shed light on this issue.

Introduction

Medulloblastoma is a frequent childhood brain tumor which may occur in the vermis, cerebellum and posterior fossa [1]. Medulloblastoma may be seen in the midline arising from anterior portion of vermis and then may grow into the inferior or superior velum of fourth ventricle. Affected patients may suffer from a variety of symptoms due to elevated intracranial pressure and may present with headaches, nausea and vomiting, cranial deficits, truncal ataxia, titubation of the head, alterations in mental status and gait disturbances. Tumors may arise in the vermis or cerebellar hemispheres.

Radiation Therapy (RT) plays an integral part in management of medulloblastoma and there have been several improvements over the years with introduction of modernized equipment and treatment delivery techniques [2-4]. Promising treatment outcomes and long term survival may be achieved with contemporary therapeutic strategies, however, there is still room for further improvements given that radiation induced adverse effects may still constitute a critical concern for these patients [5]. Within this context, effort is focused on improving the toxicity profile of radiation delivery to improve the therapeutic ratio. Protection of critical structures and surrounding normal tissues has been a very relevant aspect of contemporary RT practice in the millennium era. Accuracy in

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target and treatment volume definition has been thoroughly studied to achieve better outcomes. From the perspective of radiation oncology, there have been rapid developments in recent years with excellent advances in with introduction of adaptive irradiation strategies and modernized treatment delivery techniques with incorporation of Image Guided Radiation Therapy (IGRT), Intensity Modulated Radiation Therapy (IMRT), Adaptive Radiation Therapy (ART), Breathing Adapted Radiation Therapy (BART), molecular imaging methods, automatic segmentation techniques, and stereotactic irradiation strategies [6-41]. Herein, we assessed posterior fossa target definition by multimodality imaging patients with medulloblastoma.

Materials and methods

In this study, posterior fossa target definition with multimodality imaging by incorporation of Magnetic Resonance Imaging (MRI) or by Computed Tomography (CT)-simulation images only was evaluated comparatively for patients with medulloblastoma. Board certified radiation oncologists have outlined the ground truth target volume as the reference for actual treatment and for comparison purposes after thorough assessment, collaboration, colleague peer review, and ultimate consensus. Meticulous patient assessment was performed for consideration of lesion size and localization, symptomatology, preferences, logistical issues, and contemplated outcomes of therapy. Decision making for individualized patient management was performed by multidisciplinary evaluation of experts from neurosurgery, radiology, pediatric oncology, medical oncology, and radiation oncology. CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) was used for RT simulation. Planning CT images were acquired and sent to the contouring workstation (SimMD, GE, UK) for delineation of target volumes and surrounding critical structures. Either CT-simulation images only or fused CT and MR images were utilized for the purpose of posterior fossa target volume determination for RT. Posterior fossa target determination with CT only and with incorporation of CT-MR fusion was evaluated with comparative analysis. Synergy (Elekta, UK) linear accelerator (LINAC) was utilized for treatment delivery with routine incorporation of IGRT with electronic portal imaging and kilovoltage cone beam CT.

Results

RT planning was performed by use of the available treatment planning systems at our tertiary referral institution with prioritization of target coverage and normal tissue sparing to improve the therapeutic ratio. Board certified radiation oncologists defined the ground truth target volume as the reference for actual treatment and for comparison purposes after thorough assessment, collaboration, colleague peer review, and ultimate consensus. Decision making for individualized patient management was performed by multidisciplinary evaluation of experts from neurosurgery, radiology, pediatric oncology, medical oncology, and radiation oncology. Synergy (Elekta, UK) LINAC was used for RT administration. Posterior fossa target determination with CT only and with incorporation of CT-MR fusion was evaluated with comparative analysis. There was 100% overlap between CT-MR fusion based target volume determination and ground truth target volume definition by the board certified radiation oncologists after detailed evaluation, colleague peer review, collaboration, and ultimate consensus. In this context, ground truth target volume was found to be identical with target volume definition with CT-MR fusion based imaging as the result of this study.

Discussion

Medulloblastoma is a frequent brain tumor which may cause severe symptoms in affected patients. A plethora of symptoms may result from inreased intracranial pressure and patients may suffer from headaches, nausea and vomiting, cranial deficits, truncal ataxia, titubation of the head, alterations in mental status and gait disturbances. Multidisciplinary management of medullablostama has evolved over the years to achieve the best therapeutic outcomes with combinations of surgery, systemic treatment, and RT. RT plays a major role in patient management, and contemporary strategies are being utilized for improving the toxicity profile of radiation delivery. Nevertheless, there seems to be room for further achievements considering that RT morbidity and toxicity may comprise an important concern for affected patients [5]. Adverse effects of irradiation may include fatigue, anorexia, skin reactions such as hyperpigmentation and alopecia, hearing impairment, and central nervous system toxicities such as headache, nausea and vomiting. Also, hematological toxicity in the form of anemia, leukopenia, and thrombocytopenia may occur during the RT course which may result in treatment interruptions. In this context, improving the toxicity profile of radiation delivery has been a critical aspect of medulloblastoma management in the millennium era.

Optimization of target and treatment volume determination is an indispensable component of successful RT applications for medulloblastoma. RT planning is typically based on CT simulation, however, MRI is the imaging modality of choice for medulloblastoma. While determination of smaller than actual treatment volumes may result in treatment failure with a progressive disease course, definition of larger than actual treatment volumes may lead to untowards radiation induced toxicity which may be of great concern particularly for pediatric patients with medulloblastoma. Within this context, combined utilization of fused CT and MR images may substantially assist in accurate target definition for precise RT. There are several studies addressing use of multimodality imaging for RT target definition [42-69]. Clearly, definition of the ground truth target volume for use in actual treatment and comparison purposes is a critical issue prone to variations stemming from probable interobserver variations. In our study, board certified radiation oncologists have outlined the ground truth target volume after thorough assessment, collaboration, colleague peer review, and ultimate consensus to achieve optimal results. We believe that this study may add to literature by addressing of multimodality imaging for posterior fossa target definition of medulloblastoma.

Conclusion

Multimodality imaging should be strongly considered

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