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Impact of Multimodality Imaging to Improve Radiation Therapy (RT) Target Volume Definition for Malignant Peripheral Nerve Sheath Tumor (MPNST)

Ferrat Dincoglan*, Omer Sager, Selcuk Demiral and Murat Beyzadeoglu

Department of Radiation Oncology, University of Health Sciences, Gulhane Medical Faculty, Ankara, Turkey

***Corresponding author:** Ferrat Dincoglan, Department of Radiation Oncology, University of Health Sciences, Gulhane Medical Faculty, Ankara, Turkey

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Abbreviations: MPNST: Malignant Peripheral Nerve Sheath Tumor; RT: Radiation Therapy; MRI: Magnetic Resonance Imaging; CT: Computed Tomography; IMRT: Intensity Modulated Radiation Therapy; IGRT: Image Guided Radiation Therapy; ART: Adaptive Radiation Therapy; BART: Breathing Adapted Radiation Therapy

ABSTRACT

Objective: Extensive effort has been focused on improving the toxicity profile of radiation delivery for malignant peripheral nerve sheath tumor (MPNST). Radiation therapy (RT) planning for MPNST is typically based on computed tomography (CT)-simulation. Nevertheless, incorporation of supplementary imaging modalities may offer great potential for improving radiotherapeutic management. Herein, we evaluated the impact of multimodality imaging to improve RT target volume definition for MPNST.

Materials and Methods: RT target volume definition for MPNST with incorporation of magnetic resonance imaging (MRI) or by use of the CT-simulation images only has been comparatively assessed. Ground truth target volume which has been utilized as the reference for actual treatment and comparison purposes was thoroughly determined by the board certified radiation oncologists after meticulous evaluation, colleague peer review, collaboration, and ultimate consensus.

Results: RT planning has been accomplished by use of precise treatment planning systems at our tertiary referal institution. Primary objectives of RT planning included adequate coverage of target volumes with optimal sparing of critical structures. Synergy (Elekta, UK) Linear Accelerator has been utilized for delivery of irradiation. Results of our study revealed that ground truth target volume was identical with target volume determination with CT-MR fusion based imaging.

Conclusion: RT target definition composes an indispensable aspect of successful radiotherapeutic management for MPNST. Incorporation of MRI in target volume definition is strongly recommended for improved accuracy and precision in radiotherapeutic management of MPNST despite the need for further supporting evidence.

Introduction

Malignant peripheral nerve sheath tumor (MPNST) is a rare subtype of soft tissue sarcoma originating from the cells of peripheral nerve sheaths, and a relatively poor prognosis may be associated with MPNST due to the risk of recurrence and metastasis [1-6]. Both children and adults may be affected with MPNST, and an association has been found between neuro fibromatozis type 1 and MPNST development. Also, prior radiation therapy (RT) history may be associated with MPNST development in some patients. Patients with MPNST may suffer from a plethora of symptoms depending on lesion location and proximity to critical neurovascular structures. An enlarging mass may be present with weakness, paresthesia, and pain symptoms. Surgery, RT, and systemic agents are among the therapeutic options with ongoing extensive research for optimal management of MPNST [7-11]. RT has been utilized for management of selected patients with MPNST [9-11]. However, radiation induced adverse effects constitute a formidable challenge in management of MPNST with RT. Within this context, extensive effort has been focused on improving the toxicity profile of radiation delivery. RT planning for MPNST is typically based on computed tomography (CT)-simulation. Nevertheless,

incorporation of supplementary imaging modalities may offer great potential for improving radiotherapeutic management. Herein, we evaluated the impact of multimodality imaging to improve RT target volume definition for MPNST.

Materials and Methods

RT target volume definition for MPNST with incorporation of magnetic resonance imaging (MRI) or by use of the CT-simulation images only has been comparatively assessed. Ground truth target volume which has been utilized as the reference for actual treatment and comparison purposes was thoroughly determined by the board certified radiation oncologists after meticulous evaluation, colleague peer review, collaboration, and ultimate consensus. Personalized assessment included the lesion location and volume, symptomatology, preferences, and projected outcomes of radiotherapeutic management for all patients. CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) available at our department has been utilized for RT planning. Acquired planning CT images have been transferred to the contouring workstation (SimMD, GE, UK) via the network for precise delineation of target volumes and critical structures in close vicinity of the target. Either CT-simulation images only or fused CT and MR images have been used in definition of target volumes for radiotherapeutic management. Target volume definition with CT only and with incorporation of CT-MR fusion has been comparatively assessed.

Results

RT planning has been accomplished by use of precise treatment planning systems at our tertiary referral institution. Primary objectives of RT planning included adequate coverage of target volumes with optimal sparing of critical structures. Definition of the ground truth target volume has been meticulously performed by the board certified radiation oncologists following thorough evaluation, colleague peer review, collaboration and ultimate consensus to be utilized for actual treatment and for comparative analysis. Synergy (Elekta, UK) Linear Accelerator has been utilized for delivery of irradiation. Target volume definition by CT-only imaging and by CT-MR fusion based imaging has been evaluated comparatively. Results of our study revealed that ground truth target volume was identical with target volume determination with CT-MR fusion based imaging.

Discussion

MPNST may have potential for recurrence and metastasis which may portend a grim prognosis in a group of affected patients. Given that patients at younger ages may suffer from MPNST, utmost consideration for adverse effects of any prescribed treatment is crucial. The discipline of radiation oncology has experienced significant advances recently with critical improvements in the context of adaptive RT approaches and state of the art treatment delivery techniques such as incorporation of Intensity Modulated Radiation Therapy (IMRT), Image Guided Radiation Therapy (IGRT), Adaptive Radiation Therapy (ART), Breathing Adapted Radiation Therapy (BART), automatic segmentation methods, molecular imaging techniques, and stereotactic irradiation strategies [12-46]. Regarding radiotherapeutic management of MPNST, good response to therapy and promising outcomes have been reported [9-11]. Nevertheless, there is still room for improvements for further substantiating the role of RT in MPNST management. Adverse effects of irradiation constitute a critical concern over radiotherapeutic management of patients particularly at earlier ages of their lifespan. A pertinent goal of RT may thus include minimized exposure of normal tissues which may be achieved through incorporation of IGRT techniques. RT target definition is a very critical component of management which may significantly affect treatment outcomes in terms of tumor control and toxicity. While irradiation of larger target volumes may result in increased adverse RT effects, targeting of smaller volumes may lead to treatment failure.

At this point, accuracy and precision in RT target definition becomes crucial. Typical RT workflow includes utilization of CT-simulation for RT planning. However, multimodality imaging with incorporation of MRI may offer several advantages including detailed characterization of growth pattern, growth dynamics and disease extent as addressed in a critical review by Salamon, et al. [47]. Several other studies have also investigated multimodality imaging based target volume definition for other tumors [48-67]. In conclusion, RT target definition composes an indispensable aspect of successful radiotherapeutic management for MPNST. Incorporation of MRI in target volume definition is strongly recommended for improved accuracy and precision in radiotherapeutic management of MPNST despite the need for further supporting evidence.

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