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Assessment of Multimodality Imaging for Target Definition of Intracranial Chondrosarcomas

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Abstract

Objective: Radiation therapy (RT) may be considered as an adjunctive treatment or in the setting of unresectability or inoperability for intracranial chondrosarcoma management. Target definition constitutes a prominent part of safe and efficacious management with irradiation. Herein, we evaluated multimodality imaging for target definition for radiotherapeutic management of intracranial chondrosarcomas.

M**aterials and methods:** In this study, we assessed target definition with multimodality imaging through incorporation of MRI for patients with intracranial chondrosarcoma. Either CT-simulation images only or fused CT and MR images were utilized for target volume definition. Comparative evaluation was made for target volume designation with CT only and by incorporation of CT-MR fusion.

Results: Target definition by CT-only imaging and by CT-MR fusion based imaging was assessed with comparison of both approaches. Ground truth target volume outlined by input from board-certified radiation oncologists following meticulous evaluation, thorough consideration, collaboration, colleague peer review, and final consensus was found to be identical with target definition by use of CT-MR fusion based imaging in this study.

Conclusion: Intracranial chondrosarcomas are relatively rare but locally aggressive tumors requiring intensive management. Irradiation may have a role in management either as an adjunctive or definitive therapeutic modality. Multimodality imaging with incorporation of MRI in target definition process may be considered given the importance of proper and precise targeting of these tumors for successful radiotherapeutic management. Clearly, there is need for further studies to shed light on this issue.

Keywords: **I**rradiation; Chondrosarcoma; Intracranial; Magnetic resonance imaging (MRI)

Abbrevations: RT: Radiation Therapy; CFRT: Conventionally Fractionated Radiation Therapy; SRS: Stereotactic Radiosurgery; FSRT: Fractionated Stereotactic Radiation Therapy; HFSRT: Hypofractionated Stereotactic Radiation Therapy; SABR: Stereotactic Ablative Body ; LINAC : Linear Accelerator; BART: Breathing Adapted Radiation Therapy; ART: Adaptive Radiation Therapy; IMRT: Intensity Modulated Radiation Therapy

Introduction

While chondrosarcoma is among the frequent primary bone malignancies, intracranial chondrosarcomas are rare tumors accounting for approximately 0.15% of all intracranial neoplasms [1,2]. Patient symptomatology depends on lesion location and association with eloquent brain areas. Intracranial chondrosarcomas may be localized at the skull base in close vicinity of vital neurovascular structures. Surgery is a principal mode of management for these tumors, however, their critical location may prevent complete surgical resection due to concerns about preservation of neurological functions and quality of life. Within this context, irradiation may be considered as an adjunctive treatment or in the setting of unresectability or inoperability. The typically radioresistant nature of these tumors may require the delivery of high radiation doses to achieve optimal therapeutic outcomes, nevertheless, critical organ dose constraints should be taken into account to avoid radiation induced adverse effects. Irradiation in the forms of conventionally fractionated radiation therapy (CFRT) or radiosurgery as Stereotactic Radiosurgery (SRS), Fractionated Stereotactic Radiation Therapy (FSRT), Hypofractionated Stereotactic Radiation Therapy (HFSRT), and Stereotactic Ablative Body Radiotherapy (SABR) may be utilized as valuable treatment modalities in the therapeutic armamentarium with encouraging outcomes for management of a plethora of central nervous system (CNS) disorders and for several other benign and malignant neoplasms [3-24].

In the context of intracranial chondrosarcoma management, several studies have suggested the utility of irradiation with contemporary radiotherapeutic approaches including particle therapy with carbon ion and protons [25-29]. Toxicity profile of irradiation is a critical aspect of management with RT considering the critical location of chondrosarcomas in the vicinity of important neurovascular structures. Thus, target definition for precise irradiation constitutes a prominent part of safe and efficacious management with irradiation. Herein, we evaluated multimodality imaging for target definition for radiotherapeutic management of intracranial chondrosarcomas.

Materials and methods

In this study, we assessed target definition with multimodality imaging through incorporation of MRI for patients with intracranial chondrosarcoma. Ground truth target volume serving as the reference to be used for actual treatment and comparison purposes was determined by radiation oncologists after meticulous assessment, colleague peer review, collaboration, and consequent consensus. Thorough individualized patient evaluation included consideration of lesion size, localization, symptoms, patient preferences, and contemplated outcomes and toxicity profile of radiotherapeutic treatment. CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) was used in treatment simulation of patients for radiation treatment planning (RTP) at our tertiary referral institution. Planning CT images were acquired and sent to delineation workstation (SimMD, GE, UK) for contouring of treatment volumes and nearby normal tissues. Either CT-simulation images only or fused CT and MR images were utilized for target volume definition. Comparative evaluation was made for target volume designation with CT only and by incorporation of CT-MR fusion. Determination of ground truth target volume was executed by radiation oncologists following meticulous assessment, collaboration, colleague peer review and final consensus to be used for actual treatment as well as for comparative evaluation. Synergy (Elekta, UK) linear accelerator (LINAC) was utilized for precise treatment delivery accompanied by routinely incorporated Image Guided Radiation Therapy (IGRT) techniques available at our tertiary cancer center.

Results

Available treatment planning systems at our department were used for RTP. Encompassing of target volume with optimal critical organ protection was prioritized to achieve an optimal therapeutic ratio. Synergy (Elekta, UK) LINAC was used for accurate and precise delivery of irradiation. Target definition by CT-only imaging and by CT-MR fusion based imaging was assessed with comparison of both approaches. Ground truth target volume outlined by input from board-certified radiation oncologists following meticulous evaluation, thorough consideration, collaboration, colleague peer review, and final consensus was found to be identical with target definition by use of CT-MR fusion based imaging in this study.

Discussion

Although relatively rare, intracranial chondrosarcomas may behave as locally aggressive tumors with preponderance for local recurrence. Irradiation by CFRT, radiosurgery, or particle therapy with incorporation of modern RT techniques may be used for optimal management of patients with intracranial chondrosarcoma. While irradiation may serve as an adjunctive therapy after incomplete surgical resection, definitive radiotherapeutic management may also be considered in the setting of unresectability or inoperability. The discipline of radiation oncology has experienced substantial progress recently with adoption of contemporary technologies, adaptive irradiation strategies and excellent treatment delivery techniques including incorporation of automatic segmentation methods, molecular imaging, Adaptive Radiation Therapy (ART), Intensity Modulated Radiation Therapy (IMRT), Image Guided Radiation Therapy (IGRT), Breathing Adapted Radiation Therapy (BART), and stereotactic irradiation with SRS, FSRT, and SABR [30-40]. Contemporary therapeutic strategies such as radiosurgical applications have great potential for focused and precise irradiation by means of rigid immobilization and may confer progress in accuracy of irradiation, however, target definition gains further importantance when relatively higher radiation doses are administered in a single or few treatment fractions. Precision and accuracy in target definition is an indispensable component in state of the art radiotherapeutic management of intracranial chondrosarcomas. Designation of larger than actual target volumes may profoundly enhance exposure of surrounding critical organs which may potentially translate into adverse radiation effects and deterioration in quality of life of affected patients. From a different standpoint, targeting of an improper treatment volume may result in geographical miss and subsequent recurrence. Nevertheless, determining the exact localization of intracranial chondrosarcomas with optimal target definition by use of multimodality imaging and IGRT techniques may offer improved precision in radiotherapeutic management of these tumors. Indeed, several other studies have also addressed the utility of multimodality imaging for target definition [41-61]. Within this context, the current study may add to the existing literature by addressing of multimodality imaging for target definition in intracranial chondrosarcoma RTP.

Conclusion

In conclusion, Intracranial chondrosarcomas are relatively rare but locally aggressive tumors requiring intensive management. Irradiation may have a role in management either as an adjunctive or definitive therapeutic modality. Multimodality imaging with incorporation of MRI in target definition process may be considered given the importance of proper and precise targeting of these tumors for successful radiotherapeutic management. Clearly, there is need for further studies to shed light on this issue.

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