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Appraisal of Target Definition for Management of Paraspinal Ewing Tumors with Modern Radiation Therapy (RT): An Original Article

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Abbreviations: AAPM: American Association of Physicists in Medicine; ICRU: International Commission on Radiation Units and Measurements; LINAC: Linear Accelerator; IGRT: Image Guided RT; ART: Adaptive RT; CT: Computed Tomography; RT: Radiation Therapy; MRI: Magnetic Resonance Imaging

ABSTRACT

Objective: Radiation therapy (RT) may be utilized as part of multidisciplinary Ewing sarcoma management. Every effort is made to avoid radiation induced toxicity in radiotherapeutic management of Ewing sarcoma. Exploitation of image guided RT (IGRT) techniques, adaptive RT, and improved target definition are among the several considerations for contemporary radiotherapeutic management with an improved toxicity profile. Currently, majority of cancer centers utilize Computed Tomography (CT) simulation for RT planning for Ewing sarcoma. While CT is an effective imaging modality, incorporation of other imaging modalities such as Magnetic Resonance Imaging (MRI) may result in improved target definition for radiotherapeutic management. In this study, we assessed RT target definition for paraspinal Ewing sarcoma by use of multimodality imaging.

Materials and Methods: Patients receiving RT for paraspinal Ewing sarcoma were assessed with comparative analysis to explore whether multimodality imaging improves target volume definition, interobserver and intraobserver variations for radiotherapeutic management of Ewing sarcoma. To address this critical issue, we comparatively assessed RT target volume determination by integration of MRI or by CT-simulation images only.

Results: Patients referred for radiotherapeutic management of paraspinal Ewing sarcoma at the Department of Radiation Oncology, Gulhane Medical Faculty, University of Health Sciences have been studied for target volume determination by either CT-only imaging or by CT-MR registration-based imaging in this original study. Ground truth target volume has been found to be identical with CT-MR registration-based imaging in this study for radiotherapeutic management of paraspinal Ewing sarcoma.

Conclusion: Our study suggests improved target volume definition for radiotherapeutic management of paraspinal Ewing sarcoma by incorporation of MRI in RT planning procedure. Admittedly, there is need for further supporting evidence.

Introduction

Ewing sarcoma, initially described by James Ewing in 1921, may be broadly categorized as a high-grade osteolytic bone tumor which may occur at several localizations throughout the skeleton albeit with a tendency to involve the diaphysis of long bones [1-11]. Children and adolescents are more frequently affected, and multidisciplinary management is required for improved therapeutic outcomes [3-11]. Radiation therapy (RT) plays a major role in treatment of Ewing sarcoma, and there have been improvements in radiotherapeutic management recently [3-11]. Since younger patients are more commonly diagnosed with Ewing sarcoma, adverse effects of irradiation should be thoroughly considered before radiotherapeutic management. While RT is a viable therapeutic option for a variety of cancers, pediatric patients should be more vigilantly considered for irradiation in view of the toxicity and consequences regarding quality of life. Younger patients still in the process of growing may be negatively affected by adverse irradiation effects. Nevertheless, RT may be utilized as part of multidisciplinary Ewing sarcoma management. Every effort is made to avoid radiation induced toxicity in radiotherapeutic management of Ewing sarcoma. Exploitation of image guided RT (IGRT) techniques, adaptive RT (ART), and improved target definition are among the several considerations for contemporary radiotherapeutic management with an improved toxicity profile. Currently, majority of cancer centers utilize Computed Tomography (CT) simulation for RT planning for Ewing sarcoma. While CT is an effective imaging modality, incorporation of other imaging modalities such as Magnetic Resonance Imaging (MRI) may result in improved target definition for radiotherapeutic management. In this study, we assessed RT target definition for Ewing sarcoma by use of multimodality imaging.

Materials and Methods

Patients receiving RT for Ewing sarcoma were assessed with comparative analysis to explore whether multimodality imaging improves target volume definition, interobserver and intraobserver variations for radiotherapeutic management of Ewing sarcoma. To address this critical issue, we comparatively assessed RT target volume determination by integration of MRI or by CT-simulation images only. Ground truth target volume has been determined for every patient on a collaborative basis by board certified radiation oncologists after detailed assessment, colleague peer review, and consensus for actual treatment and comparison purposes. Included patients had paraspinal Ewing sarcoma, and management with RT was decided after close collaboration and detailed multidisciplinary evaluation on an individual basis. We considered optimal therapeutic approaches and protocols by meticulous evaluation of patient, tumor, and treatment characteristics. Decision making procedure included thorough consideration of lesion sizes, localization and association with critical structures, contemplated outcomes of treatment, patient symptomatology and preferences along with logistical issues. RT delivery has been accomplished by use of Synergy (Elekta, UK) linear accelerator (LINAC) available at our tertiary referral institution. CT-simulation has been individually performed for each patient at the CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) to acquire high quality RT planning images. Following the CT-simulation procedure, acquired RT planning images were sent to the delineation workstation (SimMD, GE, UK) by use of the network. Structure sets including treatment volumes and critical structures have been meticulously determined. Target volume definition was performed by either the CT-simulation images only or by registered CT and MR images. We conducted a comparative analysis for assessment of target definition by CT only and with incorporation of CT-MR registration-based imaging to investigate the impact of multimodality imaging.

Results

Patients referred for radiotherapeutic management of paraspinal Ewing sarcoma at the Department of Radiation Oncology, Gulhane Medical Faculty, University of Health Sciences have been studied for target volume determination by either CT-only imaging or by CT-MR registration-based imaging in this original study. Evaluated tumor related parameters included lesion size, localization and association with the spinal cord, extent of bony invasion, and other characteristics. Additionally, patient age, symptomatology, performance status, lesion location and association with other critical structures have also been assessed. We considered the reports by American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU) in precise RT planning. In view of contemporary guidelines and clinical experience, radiation physicists have generated plans by taking into account relevant critical organ dose constraints. Tissue heterogeneity, electron density, CT number and HU values in CT images have been considered by the radiation physicist in RT planning. A critical objective of RT planning included achieving optimal target volume coverage without violation of critical organ dose constraints. The definition of ground truth target volume has beeen accomplished by board certified radiation oncologists after thorough evaluation, colleague peer review, and consensus. Ground truth target volume has been used for actual treatment and for comparison purposes. Treatment delivery with Synergy (Elekta, UK) LINAC has been performed by incorporation of IGRT techniques including the kilovoltage cone beam CT and electronic digital portal imaging. Ground truth target volume has been found to be identical with CT-MR registration-based imaging in this study for radiotherapeutic management of paraspinal Ewing sarcoma.

Discussion

Ewing sarcoma has been initially described by James Ewing in 1921 and may be defined as a high-grade osteolytic bone tumor which may occur at several localizations throughout the skeleton albeit with a tendency to involve the diaphysis of long bones [1-11]. Ewing sarcoma more frequently affects children and adolescents, and improved therapeutic outcomes may be achieved through collaborative multidisciplinary management [3-11]. RT composes a critical weapon in the therapeutic armamentarium for treatment of Ewing sarcoma, and there have been several improvements in radiotherapeutic management lately [3-11]. Given that younger patients are more frequently diagnosed with Ewing sarcoma, thorough consideration of adverse effects is mandatory. RT offers a viable therapeutic option for a variety of cancers, however, pediatric patients should be more vigilantly considered for irradiation in given the risk of toxicity and consequences affecting quality of life. Younger patients still in the process of growing may be more prone to be negatively affected by adverse irradiation effects. Even so, RT may be utilized as part of multidisciplinary Ewing sarcoma management. Every effort should be made to avoid radiation induced toxicity in radiotherapeutic management of Ewing sarcoma. Exploitation of IGRT techniques, ART, and improved target definition are among the several considerations for contemporary radiotherapeutic management with an improved toxicity profile. Multimodality imaging techniques and image fusion methods have clearly contributed to improving target definition for several cancers, and there is now growing body of evidence suggesting the use of multimodality imaging for target definition of several tumors throughout the human body [12-45].

In the meantime, majority of cancer centers utilize CT simulation for RT planning for Ewing sarcoma. CT has been an effective imaging modality, however, incorporation of other imaging modalities such as MRI may result in improved target definition for radiotherapeutic management. In this study, we assessed RT target definition for Ewing sarcoma by use of multimodality imaging and found that target definition is improved by multimodality imaging. Within this context, this study may add to accumulating body of data suggesting improved target volume definition by use of multimodality imaging. Clearly, recent years have witnessed several advances in the spectrum of radiation oncology through the introduction of molecular imaging methods, automatic segmentation techniques, stereotactic RT, intensity modulated RT (IMRT), IGRT, and ART [46-84]. In line with these innovatory advances, accuracy and precision in target volume definition has been a more critical aspect of contemporary radiotherapeutic approaches. From this perspective, we consider that our study may have relevant clinical implications for routinization of multimodality imaging for target volume definition in radiotherapeutic management of paraspinal Ewing sarcoma. In conclusion, this study suggests improved target volume definition for radiotherapeutic management of paraspinal Ewing sarcoma by incorporation of MRI in RT planning procedure. Admittedly, there is need for further supporting evidence.

Conflicts of Interest

There are no conflicts of interest and no acknowledgements.

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