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Evaluation of Target Definition by Multimodality Imaging for Management of Low-Lying Rectal Cancer with Short Course Radiation Therapy (SCRT)

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Abbreviations: SCRT: Short Course Radiation Therapy; CT: Computed Tomography; RT: Radiation Therapy; TME: Total Mesorectal Excision; MRI: Magnetic Resonance Imaging; TPS: Treatment Planning System; IGRT: Image Guided RT; ART: Adaptive Radiation Therapy; IMRT: Intensity Modulated RT; BART: Breathing Adapted Radiation Therapy

ABSTRACT

Objective: Short Course Radiation Therapy (SCRT) may allow for minimizing treatment visits which may improve patient and treatment facility convenience under the special circumstances of COVID-19 pandemic. Given the importance of precise target definition in the context of SCRT, we herein assess multimodality imaging for target definition of low-lying rectal cancers.

Materials and Methods: Contribution of multimodality imaging on target definition of low-lying rectal cancer was assessed. All included patients underwent Computed Tomography (CT)-simulation, and target definition was performed by use of CT-simulation images only or by incorporation of Magnetic Resonance Imaging (MRI).

Results: Determination of ground truth target volume has been performed after meticulous evaluation, detailed collaborative assessment, colleague peer review, and consensus by board certified radiation oncologists. Our study with the primary focus on target definition by CT-only imaging and by CT-MR registration based imaging has revealed that target definition by CT-MR registration based imaging was identical with the ground truth target volume for low-lying rectal cancer.

Conclusion: Utilization of multimodality imaging data for improved visualization and use of sophisticated image registration and fusion techniques may assist in accurate target definition for SCRT of low-lying rectal cancer despite the need for further supporting evidence.

Keywords: Low-Lying Rectal Cancer; Short Term Radiation Therapy (SCRT); Magnetic Resonance Imaging (MRI)

Introduction

Colorectal cancers are among the most frequent cancers worldwide [1,2]. Rectal cancer composes a significant proportion of colorectal cancers, and low-lying rectal cancers are an important subgroup possessing different characteristics. Patients with rectal cancer may have a pplethora of symptoms which may profoundly deteriorate quality of life. Also, morbidity and mortality due to rectal cancer is not uncommon. Within this context, rigorous management of rectal cancer is warranted to achieve optimal patient outcomes. Currently, surgical resection, systemic therapies, and Radiation

Therapy (RT) may be utilized alone or in combination with respect to disease stage, patient, tumor, and treatment characteristics. Total Mesorectal Excision (TME) has been introduced as a viable modality of surgical management leading to improved treatment results and is widely accepted as a prominent surgical approach [3]. In the context of irradiation, both short course RT (SCRT) and long course RT may be feasible and may be utilized after thorough patient evaluation and selection [4]. The recent coronavirus disease 2019 (COVID-19) pandemic came up with some administrative measures which led to modifications in treatment facility practice patterns to a large extent.

SCRT may allow for minimizing treatment visits which may improve patient and treatment facility convenience under the special circumstances of COVID-19 pandemic. Nevertheless, larger fraction size and high fractional doses should be used vigilantly to refrain from adverse radiation effects. Any deviation from accuracy in target definition may result in treatment failure or untowards toxicity. Given the importance of precise target definition in the context of SCRT, we herein assess multimodality imaging for target definition of low-lying rectal cancers.

Materials and Methods

Patients referred for SCRT for low-lying rectal cancer following thorough multidisciplinary assessment were included with consideration of suggested therapeutic strategies, patient, tumor, and treatment related features. Lesion size, localization and association with surrounding critical structures was taken into account along with symptomatology and expected outcomes of SCRT. Contribution of multimodality imaging on target definition of low-lying rectal cancer was assessed in terms of interobserver and intraobserver variations. All included patients underwent Computed Tomography (CT)-simulation, and target definition was performed by use of CT-simulation images only or by incorporation of Magnetic Resonance Imaging (MRI). A prominent group of experts have defined the ground truth target volume to be utilized for actual treatment and comparative evaluation. In this context, thorough patient assessment was performed with colleague peer review and consensus. Following treatment simulation at the CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK), acquired planning images have been transferred to the contouring workstation (SimMD, GE, UK) via the network for delineation of treatment volumes and critical structures.

We have used either CT-simulation images only or registered CT and MR images for target definition of low-lying rectal cancer. Comparative analysis has been performed to assess target definition by CT only and with incorporation of CT-MR registration. Individualized treatment dose calculation has been performed in the Treatment Planning System (TPS) unit by accounting for electron density, CT number and HU values in CT images with consideration of tissue heterogeneities. Synergy (Elekta, UK) linear accelerator (LINAC) was used for SCRT with daily incorporation of image guidance by electronic digital portal imaging and kilovoltage cone beam CT.

Results

Critical organ dose limitations were considered on an individual basis and requirements of optimal treatment planning were taken into account in light of recent guidelines along with reports of American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU). Treatment dose calculation has been carried out by considering the tissue heterogeneity, electron density, CT number and HU values in CT images. Coverage of treatment volumes has been a priority in treatment planning by expert radiation physicists while maintaining optimal normal tissue sparing. Determination of ground truth target volume has been performed after meticulous evaluation, detailed collaborative assessment, colleague peer review, and consensus by board certified radiation oncologists. We used the graound truth target volume for actual treatment and also for comparative evaluation. Treatment delivery has been accomplished by use of Synergy (Elekta, UK) LINAC with daily integration of image guidance by kilovoltage cone beam CT and electronic digital portal imaging. Our study with the primary focus on target definition by CT-only imaging and by CT-MR registration based imaging has revealed that target definition by CT-MR registration based imaging was identical with the ground truth target volume for low-lying rectal cancer.

Discussion

Colorectal cancer comprises a major public health concern as a leading cause of cancer related morbidity and mortality around the globe [1,2]. Among the group of colorectal cancers, low-lying rectal tumors require utmost attention with their characteristics. Prognosis for low-lying rectal cancers may be relatively poorer. This may be in part due to difficulties in surgical management, absence of peritoneum as a barrirer to tumor spread, and possible tendency for systemic metastases. Within this context, optimal management of low-lying rectal cancer poses a formidable challenge to the treating physicians. Surgical techniques, systemic therapy strategies, and RT have evolved over time and significant advances have occurred in recent years. COVID-19 pandemic has resulted in critical modifications in treatment practice, and the utility of SCRT has been revisited in the meantime. Improving patient and treatment facility convenience under the special circumstances of COVID-19 pandemic has been a critical endpoint in decision making

for patient management. In the context of rectal cancer, SCRT has been well recognized within the scientific community as a viable mode of radiotherapeutic management.

Using condensed treatment schedules has been more popular during the COVID-19 pandemic with shorter overall treatment time. This may clearly have implications for improved utilization of available sources, reduced contact and treatment visits under the special circumstances of COVID-19 pandemic. Nevertheless, the utility of SCRT has been assessed for rectal cancer for a long time, and its safety and efficacy as a viable alternative to long course RT has been supported by high level evidence [4]. Clearly, the use of large fraction size and high fractional doses should be performed vigilantly. Image guidance and image registration methods may aid in improving radiotherapeutic management. Target definition composes an integral part of optimal radiotherapeutic management. While determination of larger than actual treatment volumes may profoundly increase toxicity, definition of smaller than actual treatment volumes may lead to geographic misses and resultant treatment failures. In the awareness of this critical situation, there is need for exploiting the advantage of multimodality imaging. CT has the inherent limitation of low contrast resolution which renders detailed assessment of rectal wall layers and the sphincter rather complex.

MRI with appropriate slice thickness may significantly improve rectal cancer imaging for RT target definition [5,6]. In clinical practice, CT-simulation is typically performed for radiation treatment planning in majority of cancer therapy centers. MRI may provide additional information which may assist is precise and accurate target definition. The superior contrast resolution of MRI may offer several clinical implications regarding SCRT for low-lying rectal cancer. Currently, threre has been an increasing trend towards utilization of multimodality imaging for improved target definition of several tumors throughout the human body [7-41]. From this perspective, this study may add to the growing body of evidence regarding the incorporation of multimodality imaging based target definition for SCRT of low-lying rectal cancer. Recent years have witnessed several improvements in radiation oncology discipline with incorporation of contemporary therapeutic equipment and adaptive irradiation strategies, Image Guided RT (IGRT), Adaptive Radiation Therapy (ART), Intensity Modulated RT (IMRT), Breathing Adapted Radiation Therapy (BART), molecular imaging methods, automatic segmentation techniques, and stereotactic RT [42-78]. For the meantime, introduction of sophisticated RT approaches comprises an evolving area of active investigation and there may still be room for future advances.

In conclusion, utilization of multimodality imaging data for improved visualization and use of sophisticated image registration and fusion techniques may assist in accurate target definition for SCRT of low-lying rectal cancer despite the need for further supporting evidence.

Conflict of Interest

There are no conflicts of interest and no acknowledgements.

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