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Reappraisal of Target Volume Definition for Stereotactic Body Radiation Therapy (SBRT) of Pelvic Lymph Node Metastases from Prostate Cancer: An Original Article

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ABSTRACT

Objective: High doses of irradiation may be focused on well-defined targets by use of Stereotactic Body Radiation Therapy (SBRT) under stereotactic localization, immobilization, and image guidance. The dose is better focused on the target and surrounding critical structures may be spared with SBRT due to steep dose gradients around the target. In the current study, we assessed target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).

Materials and Methods: Critical endpoint of this study has been defined as target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of CT and MRI. All included patients were referred to Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences for SBRT of pelvic lymph node metastases from prostate cancer. We conducted a comparative analysis of target volume definition by CT simulation images for radiation treatment planning and with MRI.

Results: Major goal of SBRT planning has been to achieve optimal target volume coverage without violation of critical organ dose constraints. As for the primary result of this study, we found that CT and MRI defined target volume definition resulted in differences.

Conclusion: These results may have implications for increased adoption of multimodality imaging for target volume definition for SBRT of pelvic lymph node metastases from prostate cancer, nevertheless, further thorough analysis and validation in future studies may be warranted.

Keywords: Prostate Cancer; Radiation Therapy (RT); Stereotactic Body Radiation Therapy (SBRT); Target Volume Definition

Abbreviations: AAPM: American Association of Physicists in Medicine; ICRUM: International Commission on Radiation Units and Measurements; LINAC: Linear Accelerator; CT: Computed Tomography; ART: Adaptive Rt; SBRT: Stereotactic Body Radiation Therapy; EBRT: External Beam Radiation Therapy

Introduction

Prostate cancer remains to be a major public health concern with its high incidence globally [1-3]. While the disease may be more commonly diagnosed at earlier stages thanks to improved screening programs, both the disease itself and therapeutic approaches used for management may deteriorate patients' quality of life. Surgery, radiation therapy (RT), hormonotherapy and systemic agents may be used for prostate cancer management [2-7]. For irradiation, several techniques including external beam radiation therapy (EBRT), Stereotactic Body Radiation Therapy (SBRT), and brachytherapy may be utilized with regards to patient, disease, and treatment characteristics. Pelvic lymph node metastases from prostate cancer may be encountered during the course of disease, and management of these metastases is of utmost importance. Indeed, utilization of higher RT doses may contribute to improved local control outcomes for prostate cancer, nevertheless, toxicity profile of radiation delivery should also

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be taken into account to avoid excessive radiation induced toxicity. Admittedly, recent years have witnessed many advances in technology. Automatic segmentation techniques, molecular imaging methods, Image Guided RT (IGRT), Intensity Modulated RT (IMRT), stereotactic RT, and adaptive RT (ART) have been introduced for optimal radiotherapeutic management of patients [8-49]. SBRT may serve as an excellent tool for management of oligometastatic disease.

High doses of irradiation may be focused on well-defined targets by use of SBRT under stereotactic localization, immobilization, and image guidance. The dose is better focused on the target and surrounding critical structures may be spared with SBRT due to steep dose gradients around the target. As a relatively newer irradiation technique, SBRT has been increasingly utilized for improved radiotherapeutic management of several cancers. Clearly, it should be bearded in mind that improved treatment results may only be achieved through close collaboration among related disciplines for cancer management. From this standpoint, tumor boards may contribute to bringing together surgical oncologists, radiation oncologists, medical oncologists, imaging and other relevant specialists to discuss about patient, tumor, and treatment characteristics. While surgery may play a critical role for optimal management of prostate cancer, irradiation may serve as a complementary or alternative therapeutic strategy in certain circumstances. In the current study, we assessed target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).

Materials and Methods

Here at Department of Radiation Oncology at University of Health Sciences, we have long been treating a high patient population from several places from Turkey and abroad. Using state of the art irradiation techniques, several benign and malignant tumors are irradiated at our tertiary cancer center. Critical endpoint of this study has been defined as target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of CT and MRI. All included patients were referred to Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences for SBRT of pelvic lymph node metastases from prostate cancer. We conducted a comparative analysis of target volume definition by CT simulation images for radiation treatment planning and with MRI. CT simulations of the patients were done at CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) available at our department. Also, MRI of patients have been acquired and used for comparative evaluation. A Linear Accelerator (LINAC) with the capability of sophisticated IGRT techniques has been utilized for irradiation. After rigid patient immobilization, planning CT images were acquired at CT-simulator for radiation treatment planning. Thereafter, acquired SBRT planning images have been transferred to the delineation workstation by use of the network. Treatment volumes and nornal tissues have been defined on these images and structure sets were generated. Also, target definition has also been performed on MRI for comparison purposes. All patients have been treated by using SBRT at Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences.

Results

This study has mainly focused on evaluation of treatment volume determination target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of CT and MRI. Stereotactic irradiation procedures have been performed at our Radiation Oncology Department of Gulhane Medical Faculty at University of Health Sciences, Ankara. Prior to SBRT, all included patients have been individually assessed by a multidisciplinary team of experts from surgical oncology, radiation oncology, and medical oncology. We took into account the reports by American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU) for precise SBRT planning. Radiation physicists took part in generation of SBRT treatment plans by considering relevant critical organ dose constraints through utmost consideration of contemporary guidelines and clinical experience. Also, published international guidelines and consensus recommendations for RT contouring and treatment of prostate cancer were considered. Tissue heterogeneity, electron density, CT number and HU values in CT images have also been considered by radiation physicists for precise SBRT planning. Major goal of SBRT planning has been to achieve optimal target volume coverage without violation of critical organ dose constraints. IGRT techniques including kilovoltage cone beam CT were utilized, and radiation treatment has been performed by Synergy (Elekta, UK) LINAC. As for the primary result of this study, we found that CT and MRI defined target volume definition resulted in differences. Taking this into account, fusion of CT and MRI has been performed for ground truth target volume definition for SBRT.

Discussion

Prostate cancer remains to be a major public health concern with its high incidence globally [1-3]. While the disease may be more commonly diagnosed at earlier stages thanks to improved screening programs, both the disease itself and therapeutic approaches used for management may deteriorate patients' quality of life. Surgery, RT, hormonotherapy and systemic agents may be used for prostate cancer management [2-7]. For irradiation, several techniques including EBRT, SBRT, and brachytherapy may be utilized with regards to patient, disease, and treatment characteristics. Pelvic lymph node metastases from prostate cancer may be encountered during the course of disease, and management of these metastases is of utmost importance. Indeed, utilization of higher RT doses may contribute to improved local control outcomes for prostate cancer, nevertheless, toxicity profile of radiation delivery should alson be taken into account to avoid excessive radiation induced toxicity. Admittedly, recent years have witnessed many advances in technology. Automatic segmentation techniques, molecular imaging methods, IGRT, IMRT, stereotactic RT, and ART have been introduced for optimal radiotherapeutic management of patients [8-49]. SBRT may serve as an excellent tool for management of oligometastatic disease. High doses of irradiation may be focused on well-defined targets by use of SBRT under stereotactic localization, immobilization and image guidance. The dose is better focused on the target and surrounding critical structures may be spared with SBRT due to steep dose gradients around the target.

As a relatively newer irradiation technique, SBRT has been increasingly utilized for improved radiotherapeutic management of several cancers. Clearly, it should be beared in mind that improved treatment results may only be achieved through close collaboration among related disciplines for cancer management. From this standpoint, tumor boards may contribute to bringing together surgical oncologists, radiation oncologists, medical oncologists, imaging and other relevant specialists to discuss about patient, tumor, and treatment characteristics. While surgery may play a critical role for optimal management of prostate cancer, irradiation may serve as a complementary or alternative therapeutic strategy in certain circumstances. In the current study, we assessed target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of CT and MRI. Critical endpoint of this study has been defined as target volume definition for SBRT of pelvic lymph node metastases from prostate cancer with comparative analysis of CT and MRI. All included patients were referred to Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences for SBRT of pelvic lymph node metastases from prostate cancer. We conducted a comparative analysis of target volume definition by CT simulation images for radiation treatment planning and with MRI. Major goal of SBRT planning has been to achieve optimal target volume coverage without violation of critical organ dose constraints. IGRT techniques including kilovoltage cone beam CT were utilized, and radiation treatment has been performed by Synergy (Elekta, UK) LINAC. As for the primary result of this study, we found that CT and MRI defined target volume definition resulted in differences. Taking this into account, fusion of CT and MRI has been performed for ground truth target volume definition for SBRT.

From the standpoint of radiation oncology, optimal target volume definition and critical organ sparing may be considered among the critical components of optimal radiotherapeutic management. While determination of larger treatment volumes might result in excessive radiation induced toxicity, definition of smaller treatment volumes may lead to treatment failures. Adaptive RT strategies and multimodality imaging-based target definition have been suggested for achieving improved outcomes [50-106]. In the current study, we found that CT and MRI defined treatment volume determination resulted in differences. Taking this into account, fusion of CT and MRI was utilized for ground truth treatment volume definition. These results may have implications for increased adoption of multimodality imaging for target volume definition for SBRT of pelvic lymph node metastases from prostate cancer, nevertheless, further thorough analysis and validation in future studies may be warranted.

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