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Treatment Volume Determination in Small Cell Lung Cancer Patients

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Abstract

Objective: In this study, we evaluated treatment volume determination with PET-CT fusion for small cell lung cancer.

Materials and methods: Primary goal of this study has been to evaluate treatment volume determination for fused PET-CT in patients with small cell lung cancer. We have carried out a comparative analysis of treatment volume determination by CT simulation images only or by integration of PET. While we primarily focused on evaluation of incorporated multimodality imaging for treatment volume determination, we also assessed critical organ contouring along with interobserver and intraobserver variations. Ground truth target volume has been utilized for comparative analysis, and it was determined by board certified radiation oncologists after detailed evaluation of all imaging and relevant data with thorough colleague peer review and consensus.

Results: Ground truth target volume was used as the reference for comparative evaluation, and our results revealed that use of fused PET-CT based treatment volume determination was identical with ground truth target definition in our selected group of patients with small cell lung cancer.

Conclusion: Multimodality imaging may be suggested to improve target definition for PET-CT fusion in patients with small cell lung cancer despite the need for further supporting evidence.

Keywords: Fusion; Small cell lung cancer; Radiation therapy (RT); PET (positron emission tomography)

Introduction

Small cell lung cancer (SCLC) is a poorly differentiated neuroendocrine tumor that represents approximately 15 percent of all lung cancers. Nearly all patients with SCLC are current or former smoker. SCLC is distinguished from non-small cell lung cancer (NSCLC) by its pathologic features. Clinically, it is distinguished by its rapid doubling time and high growth fraction, and the early development of metastases. SCLC usually presents with disseminated disease, and treatment strategies have been largely focused on systemic therapy. For patients with limited-stage (LS) disease, treatment usually also includes radiation therapy (RT) directed toward thoracic disease, as well as prophylactic treatment of the brain. In the uncommon circumstance that SCLC presents as a single pulmonary nodule, surgery may be a component of multimodality treatment [1-7].

For patients with extensive-stage disease, the mainstay of treatment is chemotherapy plus immunotherapy. RT to the chest and brain may be offered in select circumstances. While the use of high effective doses may clearly contribute to improved local control outcomes, adverse effects of irradiation should also be considered to maintain patient's quality of life. In the millenium era, there have been several advances in technology which improved the delivery of irradiation. Molecular imaging methods, automatic segmentation techniques, Image Guided RT (IGRT), Intensity Modulated RT (IMRT), stereotactic RT, and adaptive RT (ART) have been introduced for facilitating optimal radiotherapeutic management of patients [8-49]. Admittedly, best therapeutic results could be obtained through close collaboration among related disciplines for cancer management.

Tumor boards bring together surgical oncologists, radiation oncologists, medical oncologists, imaging and other relevant specialists to discuss about patient, tumor, and treatment characteristics to find out the management strategy for individualized optimal management. From the standpoint of radiation oncology,

optimal target volume determination and normal tissue sparing are among the critical consideration optimal radiotherapeutic management. While definition of larger target volumes may results in excessive radiation induced toxicity, determination of smaller treatment volumes may eventually lead to treatment failure. Within this context, efforts to improve target definition may translate into improved radiotherapeutic results from the perspectives of local control and toxicity. For the time being, Computed Tomography (CT) simulation constitutes the commonly practiced method for acquisition of radiation treatment planning images, however, inclusion of other imaging modalities such as PET-CT may potentially add to the accuracy of target definition which has been addressed by other studies [50-99]. In this study, we evaluated treatment volume determination for small cell lung cancer.

Materials and Methods

For several decades, we have been treating a high patient population from many places from Turkey and abroad at Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences. Within this prospect, a plethora of benign and malignant tumors have been irradiated at our tertiary cancer center for a long time. Primary goal of this study has been to evaluate treatment volume determination for small cell lung cancer based on PET and CT fusion. We have carried out a comparative analysis of treatment volume determination by CT simulation images only or by integration of PET. While we primarily focused on evaluation of incorporated multimodality imaging for treatment volume determination, we also assessed critical organ contouring along with interobserver and intraobserver variations. Ground truth target volume has been utilized for comparative analysis, and it was determined by board certified radiation oncologists after detailed evaluation of all imaging and relevant data with thorough colleague peer review and consensus. Decision making procedure for individualized patient management has involved multidisciplinary input from experts on surgical oncology, radiation oncology, medical oncology. Patient, disease, and treatment related factors were all considered. Patient age, previous treatments, symptomatology, lesion size, performance status, lesion localization and association with normal tissues, contemplated outcomes of alternative treatment alternatives, patient preferences and logistical issues have also been taken into account.

A Linear Accelerator (LINAC) furnished with sophisticated IGRT techniques has beeen utilized for RT. Following robust patient immobilization, planning CT images were obtained at CT simulator for radiation treatment planning. Then, acquired RT planning images have been transferred to the delineation workstation via the network. Treatment volumes and normal tissues have been outlined on these images and structure sets have been generated. Either CT simulation images only or fused CT-MR images have been used for assessment and comparative data analysis.

Results

We designated this original research article to assess the utility of multimodality imaging with incorporation of PET-CT fusion for treatment volume determination in a selected group of patients with small cell lung cancer. Irradiation of patients was performed at our Radiation Oncology Department of Gulhane Medical Faculty at University of Health Sciences, Ankara. Before irradiation, patients were individually evaluated by multidisciplinary collaboration of surgical oncology, medical oncology and radiation oncology disciplines. Briefly, we executed a comparative analysis based on either CT only imaging or by fused PET-CT to evaluate the use of this sophisticated strategy. Optimal RT planning procedure included consideration of lesion sizes, localization, and association with nearby critical structures. Radiation physicists were included in RT planning process with consideration of reports by American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU). Precise RT planning process included consideration of electron density, tissue heterogeneity, CT number and HU values in CT images. Primary objective of RT planning has been to achieve optimal coverage of treatment volumes along with minimized exposure of surrounding critical structures. Ground truth target volume was used as the reference for comparative evaluation, and our results revealed that use of fused PET-CT based treatment volume determination was identical with ground truth target definition in our selected group of patients with small cell lung cancer.

Discussion

Lung cancer is currently the most frequently diagnosed malignant disease worldwide and radiotherapy has a fundamental and irreplaceable role in the therapeutic algorithm of this disease. Conventionally, radiotherapy is planned using CT alone. However, this could be a source of many inaccuracies and errors in the process of contouring the target volumes, the likelihood of which could be decreased by using the data from PET imaging and, ideally, from a fusion of PET and CT (as has already been proven in the diagnosis of lung cancer).

Investigation of PET/CT imaging is a useful tool leading to increased accuracy of contouring of the target volumes. The integration of both diagnostic modalities reduces the limitations of these modalities if used separately. The use of combined PET/CT imaging often leads to an identification of a change in tumor size (it also often uncovers distant metastases) resulting in a change of treatment intention. The change of the target volume size and thus the change of irradiated volume of critical structures could lead to an increase of the dose delivered to the tumor in situations when a reduction of these volumes was reached. Investigation of PET/CT imaging also has a positive impact on subjective approach to contouring by different radiation oncologists.

While the use of high effective doses may clearly contribute to improved local control outcomes, adverse effects of irradiation

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should also be considered to maintain patient's quality of life. In the millenium era, several advances in technology have occurred which improved the delivery of irradiation. Molecular imaging methods, automatic segmentation techniques, Image Guided RT (IGRT), Intensity Modulated RT (IMRT), stereotactic RT, and adaptive RT (ART) have been introduced for facilitating optimal radiotherapeutic management of patients [8-49]. As a matter of fact, best therapeutic results might be acquired by close collaboration of related disciplines for cancer management.

Tumor boards bring together surgical oncologists, radiation oncologists, medical oncologists, imaging and other relevant specialists to discuss about patient, tumor, and treatment characteristics to find out the management strategy for individualized optimal management. From the standpoint of radiation oncology, optimal treatment volume determination and critical organ sparing are among the critical considerations for optimal radiotherapeutic management. While definition of larger target volumes may result in excessive radiation induced toxicity, determination of smaller treatment volumes may eventually lead to treatment failure. Within this context, efforts to improve target definition may translate into improved radiotherapeutic results from the perspectives of local control and toxicity. Several other studies have also addressed the utility of multimodality imaging for improved target definition [50-99]. In this study, we have assessed treatment volume determination for small cell lung cancer and found out that multimodality imaging improves this critical procedure of target definition. Multimodality imaging may be suggested to improve target definition for PET and CT fusion in patients with limited stage small lung cancer despite the need for further supporting evidence.

Conflict of Interest and Acknowledgement

There are no conflicts of interest and no acknowledgement.

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