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Evaluation of Treatment Volume Determination for Anaplastic Oligodendrogliomas Based on Multimodality Imaging: An Original Article

Anaplastik Oligodendrogliomada Görüntüleme Yöntemlerinin Radyoterapi Tedavi Volümünü Belirlemedeki Etkisi

Mustafa Akin[1,2*], Mürsel Düzova[3,4]

[1,2] Atatürk Şehir Hastanesi, Celal Bayar Üniversitesi Tıp Fakültesi, Anesteziyoloji ve Reanimasyon Anabilim Dalı, Manisa, Türkiye.
[3,4] Selçuk Üniversitesi, Celal Bayar Üniversitesi Sağlık Hizmetleri Meslek Yüksekokulu, Manisa, Türkiye.

e-mail: dr.mustafaakin@gmail.com, mursel_duzova@hotmail.com,
ORCID: 0000-0001-6570-5405
ORCID: 0000-0003-1036-2593
*Sorumlu Yazar / Corresponding Author: Mustafa Akin

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Öz

Giriş ve Amaç: Dünya Sağlık Örgütü (WHO) derece 3 anaplastik oligodendroglioma manajmanında radyasyon tedavisinin (RT) rolü bilinmektedir. Bununla birlikte, WHO derece 3 anaplastik oligodendrogliomanın radyoterapötik manajmanı için optimal hedef tanımının açıklığa kavuşturulması gerekmektedir. Bu bağlamda, bu orijinal araştırma makalesinde, WHO derece 3 anaplastik oligodendroglioma için multimodalite görüntülemeye dayalı tedavi hacminin belirlenmesi değerlendirilmektedir.
Gereç ve Yöntemler: Bu orijinal araştırma makalesinde, WHO derece 3 anaplastik oligodendroglioma için RT alan hastalarda MRI dahil edilerek veya yalnızca CT simülasyon görüntüleri ile RT tedavi hacminin belirlenmesi karşılaştırmalı olarak değerlendirildi.
Bulgular: 6 MV fotonlarla tedavi için VersaHD (Elekta, UK) Lineer Hızlandırıcı (LINAC) kullanıldı. Tedavi doğrulaması için IGRT teknikleri kullanıldı. Gerçek tedavi ve karşılaştırma amaçlı referans olarak temel gerçek hedef hacmi kullanılmış ve bireysel bazda titiz bir değerlendirmeden sonra belirlenmiştir. Çalışmanın birincil sonuç ölçütü, yalnızca BT görüntüleme ve BT-MR füzyon tabanlı görüntüleme yoluyla tedavi hacmi belirlemenin karşılaştırmalı değerlendirmesiydi. Bu çalışma, temel gerçek hedef hacminin, CT-MR füzyon tabanlı görüntüleme ile tedavi hacmi tanımıyla aynı olduğunu ortaya koydu.
Sonuç: Bu çalışma, MRG'nin tedavi planlama prosedürüne dahil edilmesiyle WHO derece 3 anaplastik oligodendrogliomlar için tedavi hacmi belirlemesinin iyileştiğini ortaya koymaktadır. Açıkçası, bu konuyu aydınlatmak için daha fazla çalışmaya ihtiyaç vardır.
Anahtar kelimeler: WHO grade 3 anaplastik oligodendroglioma, radyoterapi, manyetik rezonans görüntüleme

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Abstract

Objective: Utility of radiation therapy (RT) has been well established for management of World Health Organization (WHO) grade 3 anaplastic oligodendroglioma. Nevertheless, optimal target definition for radiotherapeutic management of WHO grade 3 anaplastic oligodendroglioma requires elucidation. Within this context, treatment volume determination for WHO grade anaplastic oligodendroglioma based on multimodality imaging is assessed in this original research article.

Materials and methods: Treatment volume determination for RT by incorporation of MRI or by CT-simulation images only was comparatively assessed for patients receiving RT for WHO grade 3 anaplastic oligodendroglioma in this original research article.
Results: VersaHD (Elekta, UK) Linear Accelerator (LINAC) was used for treatment with 6 MV photons. IGRT techniques were utilized for treatment verification. Ground truth target volume was used as the reference for actual treatment and for comparison purposes, and it was determined after meticulous evaluation on an individual basis. Primary outcome measure of the study was comparative assessment of treatment volume determination by either CT-only imaging and by CT-MR fusion based imaging. This study revealed that the ground truth target volume was identical with treatment volume definition by CT-MR fusion based imaging.
Conclusion: This study reveals improved treatment volume determination for WHO grade 3 anaplastic oligodendrogliomas by incorporation of MRI in the treatment planning procedure. Clearly, further studies are warranted to shed light on this issue.

Keywords: Radyoterapi, Manyetik Rezonans Görüntüleme, WHO Grade 3 Anaplastik Oligodendroglioma,

1. Introduction

Glial tumors are among the very frequent tumors of the central nervous system (CNS). Within the group of gliomas, oligodendroglial tumors account for a considerable proportion of glial tumors. Oligodendroglial tumors including oligodendrogliomas and oligoastrocytomas account for approximately 5% of primary brain malignancies [1,2]. Oligodendrogliomas are mostly localized in the frontal lobe, and men are more commonly affected as compared to women. Peak manifestation frequently occurs within the older ages of the lifespan with children being less commonly affected. Patients may suffer from a variety of symptoms depending on lesion size, localization and association with critical structures. Nevertheless, clinical presentation may take several years and seizures may be a critical presenting symptom given the high tendency of oligodendrogliomas to involve the cortical gray matter. These tumors have been graded by World Helath Organization (WHO) classification scheme based on anaplastic and astrocytic components [3,4]. According to the WHO classification, oligodendrogliomas are categorized into low grade (WHO grade 2) oligodendrogliomas and high grade or anaplastic (WHO grade 3) oligodendrogliomas [3,4]. Imaging studies are useful for diagnosis. Typically, magnetic resonance imaging (MRI) is the principal imaging modality for oligodendrogliomas and imaging characteristics may be associated with grade [5-10]. A round or oval lesion with sharp margins involving the cortex or subcortical white matter is commonly detected in imaging studies. Calcification may be observed, and cystic degeneration or hemorrhage are rarely seen. Computed tomography (CT) typically offers poorer visualization,and MRI is superior to CT in terms of defining the extent of tumor involvement. T1-weighted MRI typically shows a hypointense lesion compared to gray matter, and T2-weighted MRI demonstrates a hyperintense lesion compared to gray matter. Apparent diffusion coefficient values and advanced MRI techniques may be utilized for differentiation of grade, however, histopathological verification is required to establish exact grading of these tumors. Management strategies may differ for different grades of oligodendroglioma. Surgical resection, systemic therapies, and radiation therapy (RT) may be used for optimal treatment of anaplastic oligodendrogliomas [8-13]. Surgery is the principal modality of management which may allow for histopathological verification and reduction in the mass effect caused by the tumor. However, complete surgical resection may not be feasible in a considerable proportion of anaplastic oligodendrogliomas due to infiltrative nature of the disease resulting in poor delineation of the tumor from the normal brain parenchyma. Also, intimate association of the tumor with surrounding critical structures and localization of the tumor in eloquent brain regions may preclude optimal surgical resection. RT may be used as part of multimodality management and also as salvage therapy for recurrent disease. Utility of RT has been well established for management of WHO grade 3 anaplastic oligodendrogliomas [13-14]. Nevertheless, optimal target definition for radiotherapeutic management of WHO grade 3 anaplastic oligodendroglioma requires elucidation. Within this context, treatment volume determination for WHO grade anaplastic oligodendroglioma based on multimodality imaging is assessed in this original article.

2. Materials and methods

In this original research article, multimodality imaging based treatment volume definition was assessed for patients receiving RT for WHO grade 3 anaplastic oligodendroglioma. Treatment volume determination for RT by incorporation of MRI or by CT-simulation images only was comparatively analyzed. Ground truth target volume which served as the reference for actual treatment and for comparison purposes was defined following thorough individualized assessment. Lesion sizes, localization and association with surrounding critical structures, patient symptomatology, and expected outcomes of radiotherapeutic management were considered at the outset. All patients underwent CT-simulation at the CT-simulator (Siemens Somatom Emotion, Siemens Healthcare, Germany), and acquired planning CT images were then sent to the contouring workstation (MonacoSim, Elekta, UK) for delineation of treatment volumes and critical structures. After the contouring procedure was completed, delineation data sets have been transferred to the Elekta Monaco treatment planning system (Elekta, UK) for radiation

treatment planning. CT-simulation images only or fused CT and MR images were utilized for treatment volume determination. Treatment volume determination by CT only and with incorporation of CT-MR fusion has been assessed comparatively. Setup verification was performed by use of Image Guided Radiation Therapy (IGRT) techniques, and treatment delivery was accomplished by use of VersaHD (Elekta, UK) Linear Accelerator (LINAC) using 6 MV photons.

3. Results

In radiation treatment planning, critical organ dose limitations and requirements for optimal planning were considered according to the guidelines of American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Dose and Measurements (ICRU). Dose calculations have been performed by taking into account the electron density, CT number and HU values in CT images by considering tissue heterogeneity. Optimal coverage of the target volumes has been a priority in radiation treatment planning with optimal critical organ sparing.

VersaHD (Elekta, UK) Linear Accelerator (LINAC) was used for treatment with 6 MV photons. IGRT techniques were utilized for treatment verification. Ground truth target volume was used as the reference for actual treatment and for comparison purposes, and it was determined after meticulous evaluation on an individual basis. Primary outcome measure of the study was comparative assessment of treatment volume determination by either CT-only imaging and by CT-MR fusion based imaging. This study revealed that the ground truth target volume was identical with treatment volume definition by CT-MR fusion based imaging.

4. Discussion

Gliomas are among the most common primary brain tumors, and oligodendrogliomas comprise a considerable proporton of gliomas. Oligodendroglial tumors including oligodendrogliomas and oligoastrocytomas account for approximately 5% of primary brain malignancies [1,2]. Localization for oligodendrogliomas is frequently in the frontal lobe, and there is a male preponderance. Peak manifestation most commonly occurs within the older ages of the lifespan and children are less frequently affected. Symptoms may vary according to lesion size, localization and association with critical structures. However, seizures may be an important presenting symptom taking into account the preponderance of oligodendrogliomas to involve the cortical gray matter. Oligodendrogliomas are graded by WHO classification scheme depending on their anaplastic and astrocytic components [3,4]. As per the WHO classification, oligodendrogliomas may be classified as low grade (WHO grade 2) oligodendrogliomas and high grade or anaplastic (WHO grade 3) oligodendrogliomas [3,4]. Diagnosis may be assisted by use of imaging studies. Indeed, MRI is the main imaging modality for detection of oligodendrogliomas, and imaging characteristics may have an association with disease grade [5-10]. As compared to MRI, CT typically offers poorer visualization. MRI is superior to CT for definition of tumor extent. A hypointense lesion compared to gray matter is typical on T1-weighted MRI, and T2-weighted MRI indicates a hyperintense lesion compared to the gray matter. Advanced MRI techniques and apparent diffusion coefficient values with other relevant parameters may be used for grade differentiation. Nevertheless, histopathological verification is gold standard for exact grading of oligodendrogliomas. Treatment strategies may show differences for different grades of oligodendrogliomas. Surgery, systemic therapies, and RT may be utilized for multidisciplinary management of anaplastic oligodendrogliomas [8-21]. Surgery is the primary treatment modality for oligodendroglomas, and it allows for histopathological verification along with reduction in the mass effect caused by the tumor. Nevertheless, complete surgical removal of the lesions may not be achievable in the setting of infiltrating anaplastic oligodendrogliomas in close association with surrounding critical structures. Within this context, RT may be utilized as part of multimodality management and for salvage therapy of recurrent anaplastic oligodendrogliomas. RT has a well established role for management of WHO 3 anaplastic oligodendrogliomas [12-21]. Recent technological developments have paved the way for focused irradiation of well-defined tumors with robust immobilization and IGRT techniques. Precision in treatment volume definition has definitely emerged as an integral part of contemporary RT strategies. As a relatively newer weapon in the therapeutic armamentarium, radiosurgery has revolutionized treatment of brain tumors with exact acuracy and precision. However, tighter margins around the target volume requires optimal target definition to get rid of adverse radiation effects or geographic misses. While large margins around the target volume may result in excessive exposure of the normal brain tissues leading to adverse radiation effects, using tight margins may result in geographic misses particularly in the setting of inaccurate target definition. Within this context, exploitation of multimodality imaging for optimal target definition is of utmost importance. Indeed, the utility of multimodality imaging based target definition for brain tumors has been addressed in several studies [22]. From this standpoint, this study may have contributions to the current body of literature on optimal radiotherapeutic management of WHO grade 3 anaplastic oligodendrogliomas.

There have been unprecedented advances in the discipline of radiation oncology in the millenium era, and toxicity profile of radiation delivery has been improved through the integration of recent RT techniques. Introduction of adaptive RT approaches, Breathing Adapted Radiation Therapy (BART), IGRT, Intensity Modulated RT (IMRT), molecular imaging methods, automatic segmentation techniques, and stereotactic RT has clearly led to optimized radiotherapeutic management [23].

In conclusion, this study reveals improved treatment volume determination for WHO grade 3 anaplastic oligodendrogliomas by incorporation of MRI in the treatment planning procedure. Clearly, further studies are warranted to shed light on this issue.

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