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An Overview on the Role of MRI in Diagnosis and Management of Brain Tumors

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ABSTRACT

In brain tumors, the advanced treatment options techniques mostly depend on radiotherapy and neurosurgery, it also revolves around several factors including the type of tumor, extent, and location that are demonstrated by modern magnetic resonance imaging and positron-emission tomography scan. These modalities have high variability and lack method standardization application. The objectives of this review are to present an overview of many evidence-based published studies on neurosurgical and radiotherapeutic management of brain tumors. This review had a wide-ranging research literature strategy. PubMed electronic databases were the basic citation resources. Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, and neurosurgery) based on the mentioned factors affecting the condition. In Whole brain radiotherapy radiologists are serving as a basic component in the primary treatment for brain metastases in patients with expected higher survival rates and lower recurrence after stereo static resection surgery. The alternative for WBRT is performing hypofractionated radiation therapy, in cases that are not susceptible to perform radiosurgery or surgery. However, dosing in hypofractionated radiation therapy is still controversial.

Keywords: *Brain tumor, Imaging, Magnetic resonance, Radiotherapy*

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INTRODUCTION

Since the 1980s computed tomography modalities have been replaced by modern magnetic resonance scanners as diagnostic and method of choice in detecting brain metastatic tumors (Hassan *et al*., 2019; Moayeri *et al*., 2020). Magnetic resonance scanners have greatly evolved throughout the years, with noticeable digital and hardware improvements, including more competent gradients and accelerating magnetic field, as well as software modification, including additional evolutionary pulse sequences and more expanding imaging post-processing techniques involving analysis capabilities and extraction of the quantitative data. Now, magnetic resonance scanners, spectroscopes, and other imaging techniques have been used to collect information on intracranial tumors and metastases. There are other advanced imaging tools involving magnetic resonance imaging (MRI), spectroscopy, and positron emission tomography scan (PET) are known to help differentiate the tumor's metastatic stages and distinguish radiation necrotic abilities from an effective treatment (Pope, 2018).

In brain tumors, the advanced treatment options techniques mostly depend on radiotherapy and neurosurgery, it also revolves around several factors including the type of tumor, extent, and location that are demonstrated by modern magnetic resonance imaging and positron-emission tomography scan. These modalities have high variability and lack method standardization application (Langen *et al*., 2017; Kocher *et al*., 2020). Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, neurosurgery) based on the mentioned factors affecting the condition (Perkins & Liu, 2016).

The purpose of this review is to contribute and focus on standard radiological imaging modalities in the neurosurgical and radiotherapeutic management of brain tumors and provide a helpful practical and clinical guide of current physiological and anatomical imaging in brain tumors radiological findings.

MATERIALS AND METHODS

This review had a wide-ranging research literature strategy. PubMed electronic databases were the basic citation resources. Every collected data that is discussed in this review is collected and summarized from the year 1989 to 2020. The following keywords were used in combination on Mesh providing these search terms: ((“Brain"[Mesh] AND “Tumor” [Mesh] AND “MRI” [Mesh] “Radiotherapy” [Mesh] “Radiosurgery” [Mesh] AND “Planning” [Mesh])). Only published English documents, articles, clinical trials, and reviews were involved in this overview.

Review

Brain tumors and radiography

Many decades ago, Magnetic resonance imaging (MRI) was destined to point out delineation in brain tumors, as every suspected patient with intracranial tumors must undergo the initial assessment that involves magnetic resonance imaging. Thus, it was performed throughout a radio-oncologists routine to outcast false senses of serious familiarities regarding intracranial tumors. The distortions presented in magnetic resonance images explain the complicated relationship between radiotherapy and MRI, which sometimes might overshow predicted treatment errors introduced by magnetic resonance imaging (Kondziolka *et al*., 1992; Pötter *et al*., 1992; Sumanaweera *et al*., 1994; Khoo *et al*., 1997; Putz *et al*., 2020).

Today, multimodality therapeutic approaches including both radiotherapeutic, surgical, and in some cases undergoing adjuvant chemotherapy, are considered as the golden standard for demonstrating and evaluating the malignant brain tumor. This demonstration can be beneficial regarding notable survival advantages (Stupp *et al*., 2005; Cheng *et al*., 2014). These survival advantages are specifically maintained on patients with alarming headache symptoms who require emergent imaging **(Table 1)** (Purdy & Kirby, 2004; Perkins & Liu, 2016).

Table 1. Alarming headaches that require emergent brain imaging (Purdy & Kirby, 2004; Perkins & Liu, 2016)

Newly changes prior headaches that are acute to severe
Systemic symptoms association such as fever
Elderly patients who are older than 50 years
Constant changing in the time of occurrence especially in the early morning or at night
Patients with meningismus
Patients developing new neurological signs
Valsalva maneuver precipitates pain
Lesions that are progressive
Older or younger patients complaining of persistent severe headaches

Understanding advanced imaging and workup

Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, neurosurgery) based on the mentioned factors affecting the condition (Perkins & Liu, 2016). However, radiologists have greater capabilities in detecting tumors and their metastatic performance. The interpretation of radiological magnetic scans is one of the basic principles underlying physiologic imaging techniques **(Table 2)** (Pope, 2018).

Table 2. Biomarkers associated with MRI physiological applications in brain metastatic neuroimaging: (Pope, 2018)

Techniques	Biomarkers	Correlations
Diffusion-weighted imaging (DWI)	Acquired apparent diffusion Joint efficiency	Cytotoxicity, vasogenic edema and cellularity.
Arterial spin labeling (ASL)	Cerebral blood circulation flow	Vascularity
Diffusion tensor imaging (DTI)	Mean diffusion and fractional anisotropy	White matter tracts disruption
Dynamic susceptibility contrast (DSC)	Volume of relative cerebral blood mean transient time	Capillary proliferation, angiogenesis
Dynamic contrast-enhanced (DCE)	(Ktrans) coefficient contrast transfer	Capillary permeability

Radiotherapeutic planning

MRI sequences in stereotactic radiotherapeutics planning

Initially, using magnetic resonance imaging for radiotherapy planning demands the accuracy of the (GTV) tumor gross volume delineation in a three-dimensional space. The best modality suited for the task is isotropic 3D- sequencing, they minimize the tumor gross volume over-or underestimation due to the volume partial effects. Moreover, unlike 2D sequences, the 3D sequence continuously images the brain without gaps as it's known to be less susceptible to distortions related to B0 inhomogeneity (Putz *et al*., 2020).

If the tumor gross volume exceeds 10%, this indicates a volumetric error and is usually presented on less than 5 slices, especially in small brain metastases. However, partial volume effects are affected by the thickness of the slices and this leads to an overestimation of the tumor gross volume. Partial volume effect accumulation is required to be evaluated upon the fusion of multiple MRI series reordered on coronal or sagittal planes as it leads to inaccurate contouring of the tumor gross volume. Experiencing image gaps and thick slices can affect tumor gross volume estimation or might miss any small metastases happening (Snell *et al*., 2006; Putz *et al*., 2020).

3D magnetic resonance imaging technique has mostly used the T1-MPRAGE sequence in evaluating brain tumors and has also been included as a golden standard in the brain tumor imaging protocols. T1-SPACE (3D- turbo-spin-echo) is highly recommended for frequent use in intracranial radiotherapy, unlike the T1-MPRAGE gradient-echo sequence (Danieli *et al*., 2019; Putz *et al*., 2020). Regarding the contrast agent between white and grey matter, T1-SPACE helps the delineation of metastases and suppresses the vessels as it implements less contrast, unlike T1-MPRAGE where underestimation of the tumor boundaries might happen due to low uptake of the contrast agent (Komada *et al*., 2019; Putz *et al*., 2020).

Stereotactic radiotherapy time intervals and administration of the contrast agent

MR imaging in radiotherapeutic planning needs to be addressed in further researches. The requirements in MR imaging in routine diagnosis differs from imaging radiotherapy, the radiologists are meant to discuss different aspects and highlight important topics related to the situation. These topics must address free imaging distortions, the time interval between images, and the treatment using a 3D sequence (Putz *et al*., 2020).

WBRT- Whole brain radiotherapy

Whole-brain radiotherapy is serving as a basic component in the primary treatment for brain metastases in patients with expected higher survival rates and lower recurrence after stereo static resection surgery. However, the noticeable toxicity of whole-brain radiotherapy is undeniable in long-term sequelae and can highly impact the patient's quality of life. Moreover, several clinical trials were conducted showing serious cognitive decline that was reported (Kotecha *et al*., 2018). About 5% of the patients were presented with debilitating dementia, urinary incontinence, and gait ataxia (DeAngelis *et al*., 1989). To reduce WBRT toxicity there were significant advances in the testing and development of the technological and pharmacological design, by receiving memantine (Kotecha *et al*., 2018).

Hypofractionated radiation therapy

The alternative for WBRT is performing hypofractionated radiation therapy, in cases that are not susceptible to perform radiosurgery or surgery. Hypofractionated radiation therapy is known to have good lesion control and an acceptable toxicity profile. The dosing in hypofractionated radiation therapy is still controversial (Masucci, 2018).

CONCLUSION

Initially, the management of brain tumors should be analyzed by a multidisciplinary team (radiation oncology, medical oncology, neurosurgery) based on the mentioned factors affecting the condition. Using magnetic resonance imaging for radiotherapy planning demands the accuracy of the (GTV) tumor gross volume delineation in a three-dimensional space. The best modality suited for the task is isotropic 3D- sequencing, they minimize the tumor gross volume over-or underestimation due to the volume partial effects. The requirements in MR imaging in routine diagnosis differs from imaging radiotherapy, the radiologists are meant to discuss different aspects and highlight important topics related to the situation. In Whole brain radiotherapy radiologists are serving as a basic component in the primary treatment for brain metastases in patients with expected higher survival rates and lower recurrence after stereo static resection surgery. The alternative for WBRT is performing hypofractionated radiation therapy, in cases that are not susceptible to perform radiosurgery or surgery. However, dosing in hypofractionated radiation therapy is still controversial.

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