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Preface: Advanced Neuroimaging in Brain Tumors

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Sangam Kanekar

Imaging Findings of New Entities and Patterns in Brain Tumor: Isocitrate Dehydrogenase Mutant, Isocitrate Dehydrogenase Wild-Type, Codeletion, and MGMT Methylation

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Sangam Kanekar and Brad E. Zacharia

Molecular features are now essential in distinguishing between glioma histologic subtypes. Currently, isocitrate dehydrogenase mutation, 1p19q codeletion, and MGMT methylation status play significant roles in optimizing medical and surgical treatment. Noninvasive pretreatment and post-treatment determination of glioma subtype is of great interest. Although imaging cannot replace the genetic panel at present, image findings have shown promising signs to identify and diagnose the types and subtypes of gliomas. This article details key imaging findings in the most common molecular glioma subtypes and highlights recent advances in imaging technologies to differentiate these lesions noninvasively.

Clinical Review of Computed Tomography and MR Perfusion Imaging in Neuro-Oncology

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Austin Trinh, Max Wintermark, and Michael Iv

Neuroimaging plays an essential role in the initial diagnosis and continued surveillance of intracranial neoplasms. The advent of perfusion techniques with computed tomography and MR imaging have proven useful in neuro-oncology, offering enhanced approaches for tumor grading, guiding stereotactic biopsies, and monitoring treatment efficacy. Perfusion imaging can help to identify treatment-related processes, such as radiation necrosis, pseudoprogression, and pseudoregression, and can help to inform treatment-related decision making. Perfusion imaging is useful to differentiate between tumor types and between tumor and nonneoplastic conditions. This article reviews the clinical relevance and implications of perfusion imaging in neuro-oncology and highlights promising perfusion biomarkers.

Application of Diffusion Weighted Imaging and Diffusion Tensor Imaging in the Pretreatment and Post-treatment of Brain Tumor

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Ranliang Hu and Michael J. Hoch

Diffusion MR imaging exploits the diffusion properties of water to generate contrast between normal tissue and pathology. Diffusion is an essential component of nearly all brain tumor MR imaging examinations. This review covers the important clinical applications of diffusion weighted imaging in the pretreatment diagnosis and grading of brain tumors and assessment of treatment response. Diffusion imaging improves the accuracy of identifying treatment-related effects that may mimic tumor improvement or worsening. Fiber tractography models of eloquent white matter pathways are generated using diffusion tensor imaging. A practical and concise tractography guide is provided for anyone new to preoperative surgical mapping.

Clinical Applications of Magnetic Resonance Spectroscopy in Brain Tumors: From Diagnosis to Treatment 349

Brent D. Weinberg, Manohar Kuruva, Hyunsuk Shim, and Mark E. Mullins

Magnetic resonance spectroscopy (MRS) is a valuable tool for imaging brain tumors, primarily as an adjunct to conventional imaging and clinical presentation. MRS is useful in initial diagnosis of brain tumors, helping differentiate tumors from possible mimics such as metastatic disease, lymphoma, demyelination, and infection, as well as in the subsequent follow-up of patients after resection and chemoradiation. Unfortunately, the spectroscopic appearance of many pathologies can overlap, and ultimately follow-up or biopsy may be required to make a definitive diagnosis. Future developments may continue to increase the value of MRS for initial diagnosis, treatment planning, and early detection of recurrence.

Cellular and Molecular Imaging with SPECT and PET in Brain Tumors 363

Mohammad S. Sadaghiani, Sara Sheikhbahaei, Steven P. Rowe, Martin G. Pomper, and Lilja B. Solnes

This review highlights the 2 major molecular imaging modalities that are used in clinics, namely single-photon emission computed tomography (SPECT) and positron emission tomography (PET), and their added value in management of patients with brain tumors. There are a variety of SPECT and PET radiotracers that can allow imaging of different molecular processes. Those radiotracers target specific molecular features of tumors, resulting in improved specificity of these agents. Potential applications include staging of brain tumors and evaluating post-therapeutic changes.

Role of Functional Magnetic Resonance Imaging in the Presurgical Mapping of Brain Tumors 377

Rozita JalilianHasanpour, Elham Beheshtian, Daniel Ryan, Licia P. Luna, Shruti Agarwal, Jay J. Pillai, Haris I. Sair, and Sachin K. Gujar

When planning for brain tumor resection, a balance between maximizing resection and minimizing injury to eloquent brain parenchyma is paramount. The advent of blood oxygenation level-dependent functional magnetic resonance (fMR) imaging has allowed researchers and clinicians to reliably measure physiologic fluctuations in brain oxygenation related to neuronal activity with good spatial resolution. fMR imaging can offer a unique insight into preoperative planning for brain tumors by identifying eloquent areas of the brain affected or spared by the neoplasm. This article discusses the fMR imaging techniques and their applications in neurosurgical planning.

Imaging Surveillance of Gliomas: Role of Basic and Advanced Imaging Techniques 397

Jayapalli Rajiv Bapuraj, Krishna Perni, Diana Gomez-Hassan, and Ashok Srinivasan

It is essential to be aware of widely accepted criteria for grading of treatment response in both high-grade and low-grade gliomas. These criteria primarily take into account responses of measurable and nonmeasurable lesions on T2-weighted, fluid-attenuated inversion recovery, and postcontrast images to determine a final category of response for the patient. The additional role that other advanced imaging techniques, such as diffusion and perfusion imaging, can play in the surveillance of these tumors is discussed in this article.

Neoplastic Meningitis and Paraneoplastic Syndromes**411**

Sangam Kanekar, Thomas Zacharia, and Amit Agarwal

Neoplastic meningitis (NM) and paraneoplastic syndromes (PNSs) are a rare group of disorders present in patients with cancer. Clinical diagnosis of these conditions is challenging, and imaging and laboratory analysis play a significant role in diagnosing. Diagnosis of NM largely depends on documenting circulating tumor cells in the cerebrospinal fluid (CSF) and/or leptomeningeal and nodular enhancement on contrast-enhanced MR imaging of the brain or axial spine. PNSs encompass a variety of symptoms or syndromes. Paraneoplastic neuronal disorder diagnosis requires a multidimensional approach, high clinical suspicion, CSF and serum examination, and imaging. Neuroimaging is an integral part in the evaluation.

Imaging of Neurologic Injury following Oncologic Therapy**427**

Tao Ouyang and Sangam Kanekar

Neurologic injury arises from treatment of central nervous system malignancies as result of direct toxic effects or indirect vascular, autoimmune, or infectious effects. Multimodality treatment may potentiate both therapeutic and toxic effects. Symptoms range from mild to severe and permanent. Injuries can be immediate or delayed. Many early complications are nonspecific. Other early and delayed neurologic injuries, such as posterior reversible encephalopathy syndrome, dural sinus thrombosis, infarctions, myelopathy, leukoencephalopathy, and hypophysitis, have unique imaging features. This article reviews treatment options for neurologic malignancies and common and uncommon neurologic injuries that can result from treatment, focusing on radiologic features.

Radiogenomics of Gliomas**443**

Chaitra Badve and Sangam Kanekar

The 2016 World Health Organization brain tumor classification is based on genomic and molecular profile of tumor tissue. These characteristics have improved understanding of the brain tumor and played an important role in treatment planning and prognostication. There is an ongoing effort to develop noninvasive imaging techniques that provide insight into tissue characteristics at the cellular and molecular levels. This article focuses on the molecular characteristics of gliomas, transcriptomic subtypes, and radiogenomic studies using semantic and radiomic features. The limitations and future directions of radiogenomics as a standalone diagnostic tool also are discussed.

Imaging Mimics of Brain Tumors**459**

Joseph H. Donahue, Sohil H. Patel, Camilo E. Fadul, and Sugoto Mukherjee

Nonneoplastic entities may closely resemble the imaging findings of primary or metastatic intracranial neoplasia, posing diagnostic challenges for the referring provider and radiologist. Prospective identification of brain tumor mimics is an opportunity for the radiologist to add value to patient care by decreasing time to diagnosis and avoiding unnecessary surgical procedures and medical therapies, but requires familiarity with mimic entities and a high degree of suspicion on the part of the interpreting radiologist. This article provides a framework for the radiologist to identify “brain tumor mimics,” highlighting imaging and laboratory pearls and pitfalls, and illustrating unique and frequently encountered lesions.

Imaging of Tumor Syndromes**473**

Prem P. Batchala, Thomas J. Eluvathingal Muttikkal, and Sugoto Mukherjee

Tumor predisposition syndromes represent a heterogeneous group of multiorgan disorders, with many having substantial central nervous system involvement. This article highlights the common and uncommon manifestations of these syndromic disorders, the underlying genetic pathways, and the imaging findings. Radiologists must be aware of the diagnostic criteria, optimal imaging techniques (both for diagnosis and surveillance), as well as the innumerable imaging manifestations of these syndromes. Multidisciplinary approach and teamwork are essential in managing these patients, with imaging having a central role as more of these patients get diagnosed earlier and survive longer.