

Brain Tumors: Insights into Diagnosis, Management, and Future Perspectives

Jane Smith*

Department of Pharmacology, College of Medicine, University of Chicago, IL, United States

Corresponding Author*

Jane Smith
Department of Pharmacology,
College of Medicine,
University of Chicago,
IL, United States
E-mail: Jane.smith@178.edu

Copyright: © 2026 Smith J. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Received: November 27, 2024, Manuscript No. JMSO-24-153470;
Editor assigned: November 29, 2024, PreQC No. JMSO-24-153470 (PQ);
Reviewed: December 13, 2024, QC No. JMSO-24-153470;
Revised: February 05, 2026, Manuscript No. JMSO-24-153470 (R);
Published: February 12, 2026,
DOI: 10.35248/2376-0389.26.13.01.001-002

Abstract

Brain tumors are a heterogeneous group of neoplasms with significant implications for neurological health and overall survival. The diversity in tumor biology, from benign to highly malignant forms, complicates diagnosis and treatment. This review explores the epidemiology, classification, clinical presentation, diagnostic innovations, and therapeutic advancements in brain tumor management. Special attention is given to emerging technologies like molecular profiling and immunotherapy. Despite progress, challenges such as tumor heterogeneity, treatment resistance, and late diagnosis persist, necessitating continued research to improve patient outcomes and quality of life.

Keywords: Brain tumor • Glioma • Meningioma • Medulloblastoma • Glioblastoma multiforme • Brain metastasis • Neuro-oncology • Tumor microenvironment • Molecular genetics targeted therapy • Immunotherapy • Liquid biopsy • Diagnostic imaging • MRI • IDH mutation • MGMT promoter methylation • VEGF inhibitors • CAR-T therapy • Artificial intelligence • Radiotherapy • Chemotherapy • Tumor heterogeneity • Angiogenesis • Brain cancer • Precision medicine • Pediatric brain tumours • Neuroimaging • Stereotactic radiosurgery • Tumor markers • Translational research

Introduction

Brain tumors represent one of the most complex and challenging medical conditions, involving abnormal growths in the Central Nervous System (CNS). These tumors can either originate within the brain (primary tumors) or spread from other organs through metastasis (secondary tumors). Although primary brain tumors account for less than 2% of all cancers globally, their impact on patients and healthcare systems is substantial due to their high morbidity, neurological deficits, and mortality rates.

The complexity of brain tumors arises from their diverse biological behavior, varying tumor types, and critical location within the brain, which controls vital functions. Gliomas, including Glioblastoma Multiforme (GBM), are the most common and aggressive type of primary brain tumors. Despite aggressive multimodal treatments, including surgery, radiation, and chemotherapy, malignant brain tumors such as GBM remain largely incurable. This poor

prognosis underscores the need for early diagnosis, better therapeutic strategies, and a deeper understanding of tumor biology.

Recent advances in neuro-oncology have enhanced our understanding of brain tumor genetics, molecular markers, and tumor microenvironments. Technologies such as advanced imaging techniques, genetic profiling, and molecular biomarkers have revolutionized the diagnosis and management of brain tumors, leading to more personalized treatments. However, challenges remain, especially in overcoming the blood-brain barrier, which limits the effectiveness of many conventional therapies.

Current treatment options for brain tumors include surgical resection, radiation therapy, chemotherapy, and targeted therapies. Yet, even with these approaches, recurrence remains common, particularly for aggressive tumors like GBM. As such, research into novel therapies, including immunotherapy, gene therapy, and precision medicine, is rapidly advancing, offering hope for improved patient outcomes.

This article provides a comprehensive review of brain tumors, focusing on their classification, molecular mechanisms, diagnostic techniques, and treatment strategies. It highlights the importance of early detection, multidisciplinary care, and emerging therapies that may pave the way for more effective management of these devastating diseases.

Description

Epidemiology

Brain tumors are relatively rare, with an incidence of approximately 3–5 cases per 100,000 populations annually for primary malignant tumors and up to 20 cases per 100,000 for all brain tumors.

Key epidemiological insights:

Primary brain tumors: 1) Meningiomas (37%) and gliomas (30%) are the most common types. 2) Glioblastomas are the most aggressive and account for approximately 15% of primary brain tumors.

Secondary brain tumors: These are far more common and result from metastasis of systemic cancers, particularly lung, breast, and melanoma cancers.

Age and gender: 1) Pediatric tumors such as medulloblastomas are common in children, while glioblastomas are prevalent in adults aged 45–70. 2) Males are more likely to develop gliomas, while meningiomas are more common in females [1].

Classification

The classification of brain tumors has evolved with advances in molecular biology. The WHO classification system combines histopathological features with molecular markers [2].

Types of brain tumors

- **Gliomas:** a) Subtypes include astrocytomas, oligodendrogliomas, and ependymomas. b) Key markers: IDH mutation, MGMT promoter methylation, and 1p/19q co-deletion.

- **Meningiomas:** a) Usually benign and slow-growing. b) Classified based on grade (I-III), with atypical and anaplastic forms being more aggressive.
- **Pituitary tumors:** a) Include functioning (hormone-secreting) and non-functioning adenomas.
- **Medulloblastomas:** a) Common in children; classified into subgroups based on molecular signatures (e.g., WNT-activated, SHH-activated).
- **Metastatic tumors:** a) Represent the majority of adult brain tumors, often associated with advanced systemic cancer [3].

Clinical presentation

The clinical manifestations of brain tumors depend on their size, location, and growth rate.

Common symptoms

- **Neurological deficits:** Hemiparesis, visual disturbances, or aphasia due to local tumor effects.
- **Seizures:** Occur in 30–50% of patients, often the first sign in cortical tumours [4].
- **Increased Intracranial Pressure (ICP):** Headaches, nausea, vomiting, and papilledema are hallmark signs.
- **Cognitive and behavioral changes:** Memory impairment, personality changes, or disorientation, particularly in frontal lobe tumors.
- **Endocrine dysfunction:** Seen in pituitary tumors, causing conditions like acromegaly or Cushing's advances in diagnosis.

Advances in diagnosis

Imaging: Imaging remains central to diagnosing and characterizing brain tumors.

- **Magnetic Resonance Imaging (MRI):** Techniques such as fMRI, DTI, and MR spectroscopy offer superior spatial resolution and functional insights.
- **Computed Tomography (CT):** Useful for initial assessment, especially in emergencies.
- **PET scans:** Provide metabolic and molecular information to delineate tumor margins and evaluate treatment response [5].
- **Molecular diagnostics:** Molecular profiling has transformed brain tumor diagnostics.
- **Next-Generation Sequencing (NGS):** Identifies actionable mutations for targeted therapy.
- **Circulating tumor DNA (ctDNA):** Offers potential for non-invasive "liquid biopsies."

Treatment approaches

Surgery: Surgical resection is often the first step in managing brain tumors.

- **Maximal safe resection:** Enhances survival while minimizing neurological damage.
- **Advanced techniques:** Intraoperative MRI, neuronavigation, and awake craniotomy improve outcomes.

Radiation therapy: Radiation remains a cornerstone for both primary and metastatic brain tumors.

- **Conventional radiotherapy:** Effective for diffuse tumors.
- **Stereotactic radiosurgery:** Delivers focused high-dose radiation with minimal collateral damage [6].

Chemotherapy

- **Temozolomide:** A standard for glioblastoma; effectiveness correlates with MGMT promoter methylation.
- **Combination regimens:** Improve efficacy but may increase toxicity.

Targeted therapy: Molecularly driven treatments targeting EGFR, VEGF, and other pathways are under investigation. Bevacizumab, an anti-VEGF antibody, is FDA-approved for recurrent glioblastoma.

Immunotherapy

- **Checkpoint inhibitors:** Show promise in tumors with high mutational burden.
- **CAR-T cell therapy:** Personalized T cells are engineered to attack tumor-specific antigens.
- **Vaccines:** Experimental vaccines targeting tumor antigens like EGFRvIII are in clinical trials.

Tumor Treating Fields (TTF): This innovative modality uses alternating electric fields to disrupt tumor cell division.

Emerging research and future directions

- **Artificial Intelligence (AI):** AI-based algorithms enhance diagnostic accuracy and treatment planning.
- **Liquid biopsies:** Enable early detection and real-time monitoring of tumor progression.
- **Gene editing (CRISPR):** Holds potential for precise genetic modifications to counter tumor growth.
- **Combination therapies:** Integrated approaches using surgery, radiation, chemotherapy, and immunotherapy may overcome resistance mechanisms.

Conclusion

Brain tumors represent a diverse group of conditions with significant clinical and societal impacts. Advances in imaging, molecular diagnostics, and treatment modalities have improved our ability to diagnose and manage these challenging conditions. Surgical techniques, combined with radiation and chemotherapy, form the backbone of treatment, while emerging therapies such as targeted drugs, immunotherapy, and tumor-treating fields offer new hope.

Despite these advancements, challenges remain, particularly in early diagnosis, treatment resistance, and the management of aggressive forms such as glioblastoma. A multidisciplinary approach is essential, incorporating neurosurgeons, oncologists, radiologists, and supportive care teams to optimize patient outcomes. Furthermore, ongoing research into molecular mechanisms, biomarkers, and novel therapies is vital to overcoming existing limitations and transforming the landscape of brain tumor management.

The future of brain tumor treatment lies in personalized medicine, leveraging molecular profiling, artificial intelligence, and innovative technologies to deliver targeted and effective therapies. Collaborative efforts between clinicians, researchers, and policymakers will be key to improving the lives of patients affected by brain tumors.

References

1. Ostrom, Q. T., et al. "CBTRUS statistical report: Primary brain and other central nervous system tumors diagnosed in the United States." *Neuro Oncol* (2022).

2. Louis, D. N., et al. "WHO classification of tumors of the central nervous system." *Acta Neuropathol* (2016).
3. Stupp, R., et al. "Radiotherapy plus concomitant and adjuvant temozolomide for glioblastoma." *N Engl J Med* 352.10 (2005): 987-996.
4. Wen, P. Y., & Kesari, S. "Malignant gliomas in adults." *N Engl J Med* 359.15 (2008): 492-507.
5. Reardon, D. A., et al. "Immunotherapy for glioblastoma: Evidence and opportunities." *Clin Cancer Res* (2020).
6. Tan, A. C., et al. "Management of glioblastoma: State of the art and future directions." *CA Cancer J Clin* 70.4 (2020): 299-312.