Brain Tumours and Glioblastoma Multiforme: A Comprehensive Clinical Review with Case-Based Analysis

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***Abstract*—Brain tumours represent a heterogeneous group of intracranial neoplasms with widely varying biological behaviour, clinical presentation, and prognosis. Among them, Glioblastoma Multiforme (GBM) — classified as WHO Grade IV astrocytoma — remains the most aggressive and lethal primary brain tumour in adults, with a median overall survival of 14–16 months even with optimal multimodal therapy. This review consolidates current knowledge on the classification, pathophysiology, clinical presentation, neuroimaging characteristics, pharmacological management, and supportive care of brain tumours, with particular emphasis on GBM. A real-life case study of a 75-year-old female patient presenting with first-time generalised tonic-clonic seizures, subsequently diagnosed with GBM via MRI with spectroscopy, is analysed in depth. The case highlights the critical role of early neuroimaging, interpretation of MR spectroscopy findings, dual anti-epileptic pharmacotherapy (Levetiracetam+Lacosamide),corticosteroid use for cerebral oedema management, and the indispensable human dimension of oncological care including family counseling .The patient's clinical course— from first seizure to death in just 96 days — underscores the devastating natural history of GBM and the urgent need for heightened awareness, early diagnosis, and multidisciplinary management.**

***Index Terms*—Glioblastoma Multiforme, Brain Tumour, Seizure, MRI Spectroscopy, Levetiracetam, Lacosamide, Methylprednisolone, Intracranial Pressure, Cerebral Oedema, Neuro-oncology, Temozolomide, Multimodal Therapy**

I. INTRODUCTION

Brain tumours are abnormal masses arising from uncontrolled cellular proliferation within or adjacent to the brain parenchyma. They encompass a broad spectrum of neoplasms, both primary — originating from neural or glial tissue — and metastatic, seeded haematogenously from extracranial malignancies. The skull constitutes a rigid, non-expansile compartment; consequently, even a benign, slowly growing mass can exert catastrophic effects by raising intracranial pressure (ICP), compressing eloquent cortex, and distorting midline structures.

The global incidence of primary malignant brain tumours is approximately 3.5–4 per 100,000 person-years, with significant variation by histology and age. Glioblastoma Multiforme (GBM) accounts for approximately 48% of all malignant primary brain tumours and 15% of all intracranial neoplasms. Despite decades of research and incremental therapeutic advances, the prognosis of GBM remains dismal,with a median survival of approximately 14–16 months following the Stupp protocol (maximal safe resection followed by concurrent radiotherapy and temozolomide chemotherapy).

This paper aims to provide a structured, clinically oriented review of brain tumour biology,

symptomatology, diagnostic workup, and therapeutic management, culminating in an illustrative case study of GBM in an elderly female patient — a case rendered profoundly human by the fact that it involved the presenter's grandmother,whose journey from first seizure to death spanned a mere 96 days.

II. CLASSIFICATION OF BRAIN TUMOURS

Brain tumours are classified along two principal axes: origin and biological behaviour. The 2021 WHO Classification of Tumours of the Central Nervous System introduced integrated molecular parameters alongside histological grading.

By Biological Behaviour

- Benigntumours—slow-growing, well circumscribed rarely infiltrating. Examples: meningioma (WHO Grade I), pilocytic astrocytoma.
- Malignant tumours—rapid growth, infiltrative margins, necrosis, neovascularization.

Examples: GBM (WHO Grade IV), anaplastic astrocytoma (Grade III).

By Origin

- Primary brain tumours — originate from brain parenchyma or meninges. Includes gliomas(astrocytoma,oligodendroglioma,ependymoma), meningiomas,schwannomas,medulloblastomas.
- Metastatic brain tumours—seed from lung, breast, melanoma, renal cell carcinoma, or colorectal carcinoma. Constitute the most common intracranial malignancy overall.

A critical conceptual point: Brain tumours are not merely defined by size. Their clinical impact is dictated by site (eloquent vs non-eloquent cortex), speed of growth, degree of peritumoral oedema, ICP elevation, and disruption of neural circuitry. A small 1 cm GBM in the brainstem may prove immediately fatal, while a large meningioma of the frontal convexity may remain clinically silent for years.

III. PATHOPHYSIOLOGY

General mechanism:

Tumour growth within the fixed cranial vault inevitably raises ICP through the Monroe-Kellie doctrine: the sum of volumes of brain parenchyma, cerebrospinal fluid (CSF), and intravascular blood is constant. As tumour volume increases, compensatory displacement of CSF and venous blood is exhausted, leading to exponential ICP rise. Mass effect compresses adjacent parenchyma, distorts midline structures (midline shift), and may cause transtentorial or subfalcine herniation — neurological emergencies.

Glioblastoma — Molecular Pathophysiology

GBM is characterized by four hallmarks: uncontrolled glial cell proliferation, florid neovascularisation (via VEGF over expression), central necrosis, and pseudopalisading of tumour cells around necrotic foci —the pathognomonic histological feature. At the molecular level, GBM demonstrates:

- EGFR amplification and EGFRvIII mutation in ~40% of cases
- PTEN loss and PIK3CA mutations activating the PI3K/AKT/mTOR pathway
- CDKN2A/B deletion disrupting G1/S cell cycle arrest
- IDH1/2 wild-type status (distinguishing primary from secondary GBM)
- MGMT promoter methylation — present in ~45% and predicts temozolomide response
- TERT promoter mutations — found in >80% of GBM, associated with poor prognosis

Seizure Generation in Brain Tumours

Tumour-related epilepsy arises from cortical irritation, perilesional oedema altering neuronal membrane potentials, and disruption of inhibitory GABAergic interneurons. Sodium channel dysregulation, calcium channel dysfunction, glutamate excitotoxicity, and impaired GABA-mediated inhibition collectively lower the seizure threshold. In GBM, the incidence of seizures at presentation is approximately 20–30%, rising to 50–70% over the disease course. A generalised tonic-clonic seizure as the inaugural presentation in an elderly patient with no prior epilepsy history constitutes a red-flag neurological emergency mandating urgent neuro imaging.

IV. CLINICAL PRESENTATION: SILENT SIGNALS

Brain tumours may remain clinically occult for extended periods. When symptoms manifest, they

reflect either generalized ICP elevation or focal cortical dysfunction at the tumour site. Clinicians must maintain a high index of suspicion for the following:

Warning Signal		Mechanism		Clinical Significance
Headache—changed pattern		Raised ICP, meningeal stretch		Headache + neurological change = urgent evaluation
First-time seizure		Cortical irritation, ion channel dysregulation		Demands neuroimaging; never attribute to idiopathic epilepsy in adults >40 yrs
Vomiting without GI cause		Raised ICP stimulating vomiting centre		Morning vomiting + headache = ICP crisis
Personality/behavioural change		Frontal/limbic involvement		Irritability, forgetfulness, aggression—often dismissed as psychiatric
Focal	Neurological depict	Location specific	cortical	Hemiparesis, aphasia, vision loss, ataxia—
		damage		Later alising signs

Table 1. Warning Signs of Brain Tumours and Their Clinical Significance

Symptomatology by Tumour Location

The clinical phenotype is strongly predicted by anatomical location:

- Frontal lobe: Personality change, poor judgment, contralateral weakness, speech difficulty (dominant hemisphere), behavioural dis inhibition.
- Temporal lobe: Memory impairment, complex partial seizures, speech comprehension deficits (Wernicke's area), emotional lability.
- Parietal lobe: Contralateral sensory loss, spatial neglect, agraphia, acalculia, difficulty recognizing objects (agnosia).
- Occipital lobe:Contralateral homonymous hemianopia, visual processing deficits, formed visual hallucinations.
- Cerebellum: Ipsilateral limb ataxia, truncal instability, nystagmus, dysarthria, intention tremor.
- Brain stem: Multiple cranial nerve palsies, dysphagia, respiratory irregularity, altered consciousness, bilateral long-tract signs.

V. DIAGNOSTIC WORKUP

Structured Diagnostic Pathway

Diagnosis of a brain tumour follows a sequential, evidence-based approach integrating clinical history, neurological examination, neuroimaging, and ultimately histopathological confirmation.

- Step1—Detailed History: Symptom onset, progression, seizure semiology, headache pattern, focal deficits, family history, past oncological history.
- Step2—Neurological Examination: Cranial nerve assessment, motor power grading (MRC scale), deep tendon reflexes, cerebellar testing, cognitive screening, GCS scoring.
- Step 3 — Neuroimaging: MRI brain with gadolinium contrast is the gold standard. CT brain is utilized in acute settings when MRI is unavailable.MR spectroscopy, perfusion MRI, and fMRI provide additional metabolic, vascular, and functional mapping data.
- Step 4 — Biopsy / Histopathology: Stereotactic biopsy or intraoperative sampling confirms tumour type, WHO grade, and molecular markers (IDH, MGMT,EGFR,TERT,1p/19qco-deletionfor oligodendroglioma).

MRI Features of Glioblastoma

GBM has characteristic MRI appearances that reflect its pathological heterogeneity:

- T1post-contrast: Irregular, thick peripheral ring enhancement—reflecting blood-brain barrier breakdown at the actively proliferating tumour margin.
- T1 centre: Hypointense necrotic core — central tumour death due to inadequate vascular supply.
- T2/FLAIR: Extensive hyperintense signal — peritumoral vasogenic oedema and tumour infiltration.

- DWI: No significant restricted diffusion in most GBM (differentiates from abscess).
- GRE/SWI: Absence of blooming confirms no significant haemorrhage.
- MRSpectroscopy: Elevatedcholinepeak(membraneturnover=highcellularity),reducedNAA (neuronal loss), elevated choline:NAA ratio — pathognomonic for high-grade neoplasm.

VI. CASE STUDY: GLIOBLASTOMA IN A 75-YEAR-OLD FEMALE PATIENT

"When a Seizure Becomes a Diagnosis:A Real-Life Glioblastoma Case Study—From Emergency Presentation to MRI Interpretation, Pharmacological Management, and Human Reality"

Patient Demographics and Background

Parameter	Details
Age / Sex	75 years / Female
Comorbidities	No known major comorbidities prior to presentation
Social history	Chronic tobacco chewer (relevant carcinogen exposure)
Prior hospital admissions	None
MRI Scan Date	9 March 2025 (Report: 10 March 2025)
Radiologist	Konnect Bn Reddy (Patient ID: KBN256158)

Table 2. Patient Demographic Summary

Presenting Complaint and Emergency Course

The patient had no preceding neurological complaints, no history of headache, no focal weakness, and no prior seizure history. On 7 March 2025, she abruptly developed a generalised tonic-clonic seizure — characterised by sudden loss of consciousness, bilateral tonic stiffening followed by rhythmic clonic jerking of all four limbs. This event was immediately followed by a postictal state with loss of consciousness lasting more than 10 minutes. The family brought her to the emergency department. Initial vital signs were reassuringly normal: blood pressure, pulse rate, oxygen saturation, and respiratory rate were all within normal limits. This is a critically important teaching point—normal vital signs do not exclude a serious intracranial pathology. Normotension and normocardia may persist even in the presence of significantly raised ICP, particularly in the early compensated phase.

Neurological Examination Findings

On neurological examination, the patient was semi-conscious. Glasgow Coma Scale (GCS) was documented as 13/15 (E4V4M4 — though E4V4M4 arithmetically yields 12/15, reflecting the importance of careful GCS documentation). Crucially, limb power assessment revealed a striking asymmetry:

Limb	Side	Power (MRC)	Interpretation
Upper limb	Right(contralateral to left-sided tumour)	3/5	Moderate weakness
Lower limb	Right	3/5	Moderate weakness
Upper limb	Left	5/5	Normal
Lower limb	Left	5/5	Normal

Table 3. Motor Power Assessment on Admission (MRC Grading Scale)

The presence of right-sided hemiparesis following a first-time seizure with altered sensorium in an elderly patient is highly suggestive of a structural left hemispheric lesion and constitutes a neurological emergency mandating immediate MRI.

MRI Brain Findings (Plain and Contrast with MR Spectroscopy)

MRI brain with plain and gadolinium-enhanced sequences, supplemented by MR spectroscopy and DWI, was performed on 9 March 2025. The formal radiological report (prepared by Konnect Bn Reddy) yielded the following key findings:

- Mass lesion: A well-defined lobulated large mass (~55×31mm) in the left basal ganglia and temporal lobe region, with significant perifocal oedema causing mass effect and effacement of adjacent brain parenchyma.
- Ventricular involvement: Left lateral ventricle effaced with midline shift of ~4.6 mm towards the right — an emergency warning sign of early transtentorial herniation risk.
- Signal characteristics: Hypointenseon T1,

heterogeneous on T2, no significant restricted diffusion on DWI, no blooming on GRE — excluding haemorrhage and abscess.

- Post-contrast: Peripheral ring enhancement with central non-enhancing / necrotic areas—the classic appearance of GBM.
- MR Spectroscopy: Elevated choline peak—indicating high cellularity and rapid membrane turn over consistent with high-grade malignancy.
- Additional findings: Diffuse cerebral atrophy; multiple ill-defined T2/FLAIR hyperintensities in bilateral periventricular and subcortical whitematter—consistent with chronic small vessel ischaemic changes (age-related).
- Posterior fossa: Normal cerebellum, fourth ventricle, brainstem, and CP angles.

MRI Radiological Impression:

1. Well-defined lobulated large peripherally enhancing mass lesion with significant perifocal oedema in the left basal ganglia / temporal lobe causing mass effect and midline shift (~4.6 mm).
2. MR Spectroscopy: Elevated choline peak — S/o Possible Glioblastoma.
3. Diffuse cerebral atrophy.

Chronic small vessel ischaemic changes in bilateral periventricular and subcortical white matter.

Pharmacological Management

Emergency pharmacological management was initiated concurrently with neuroimaging. The therapeutic goals were: (a) seizure control, (b) reduction of cerebral oedema and inflammation, and (c) neuro protection. The following agents were administered:

Drug	Dose / Route	Mechanism	Rationale in GBM
Inj. Levetiracetam	500 mg IV BD	Binds SV2A synaptic vesicle protein; modulates Ca^{2}■channels and GABA release	First-line anti-epileptic in brain tumour-related seizures; no hepatic enzyme induction
Inj. Lacosamide	100 mg IV BD	Selective slow inactivation of voltage-gated sodium channels; CRMP-2 modulation	Add-on for refractory seizure control; excellent IV bioavailability
Inj. Methylprednisolone	500 mg IV BD	Glucocorticoid; reduces VEGF-mediated BBB permeability and vasogenic oedema	Rapid ICP reduction; anti-inflammatory in tumour microenvironment

Table 4. Emergency Pharmacological Regimen (Case-Specific; Physician-Directed)

The use of dual anti-epileptic therapy (levetiracetam+lacosamide) in this case reflects the severity of the seizure presentation and the need for rapid, robust seizure control in the context of a space-occupying lesion. High-dose pulse methyl prednisolone was chosen over standard dexamethasone to achieve rapid reduction of vasogenic oedema surrounding the tumour.

Clinical Course and Outcome — The Human Reality

Following stabilisation, the patient was referred for neurosurgical evaluation. In the context of her advanced age (75 years), performance status, and the eloquent location of the tumour (left basal ganglia and temporal lobe), the multidisciplinary team engaged in a complex decision-making process balancing oncological benefit against surgical risk and quality of life. The patient's family received comprehensive counselling regarding the diagnosis of GBM, its natural history, and the available therapeutic options.

Clinical Timeline:

- 7 March 2025 — First episode of generalised tonic-clonic seizures
- 9 March 2025 — MRI brain with spectroscopy performed
- 11 March 2025 — Formal diagnosis: Glioblastoma Multiforme / High-grade brain tumour
- 11 June 2025 — Patient expired

Total clinical course: 96 days from first seizure to death.

This timeline powerfully illustrates the devastating natural history of GBM, particularly in elderly

patients where aggressive resection may not be feasible. The 96-day course from first symptom to death aligns with published literature reporting median survival of 3–5 months in elderly GBM patients receiving supportive or palliative-intent treatment.

VII. MULTIMODAL MANAGEMENT OF GLIOBLASTOMA

Neurosurgical Management

Maximal safe surgical resection remains the cornerstone of GBM management. Gross total resection is associated with improved overall survival compared with subtotal resection or biopsy alone. Intraoperative adjuncts including 5-aminolevulinic acid (5-ALA) fluorescence-guided surgery, intraoperative MRI, and cortical mapping via awake craniotomy maximise extent of resection while preserving eloquent function. In elderly patients or those with poor performance status, biopsy alone may be appropriate to confirm histological diagnosis and guide systemic therapy.

Radiotherapy

Standard radiotherapy for GBM consists of 60 Gy delivered in 30 fractions over 6 weeks (conformal or IMRT technique) targeting the contrast-enhancing tumour plus a 2–3cm margin for subclinical infiltration. For elderly patients (>70 years), hypofractionated radiotherapy (40 Gy in 15 fractions) offers equivalent efficacy with reduced treatment burden. Stereotactic radiosurgery (Gamma Knife / CyberKnife) may be considered for recurrent or small-volume disease.

Chemotherapy — Temozolomide

Temozolomide (TMZ), an oral alkylating agent, is the standard chemotherapeutic agent for GBM (Stupp etal.,NEJM2005).TMZ methylates the O6 position of guanine, leading to DNA mismatch and apoptosis. MGMT promoter methylation — present in ~45% of GBM — silences the O6-methylguanine-DNA methyl transferase repair enzyme, predicting sensitivity to TMZ and superior survival outcomes. Standard regimen: concurrent TMZ 75 mg/m² daily during radiotherapy, followed by adjuvant TMZ 150–200 mg/m² for 5 days per 28-day cycle for 6 cycles.

Targeted and Molecular Therapies

Bevacizumab (anti-VEGF monoclonal antibody) is approved for recurrent GBM,improving progression-free survival though not overall survival. Tumour-treating fields (TTFields, Optune device) — delivering low-intensity alternating electric fields via transducer arrays — have demonstrated modest OS improvement in newly diagnosed GBM (EF-14 trial). Immunotherapy (checkpoint inhibitors: nivolumab, pembrolizumab) has thus far shown limited efficacy in unselected GBM populations. CAR-T cell therapy, EGFRvIII-targeted vaccines, and oncolytic virotherapy remain under active investigation.

Supportive and Palliative Care

Agent / Intervention	Purpose
Dexamethasone 4–8 mg BD	Reduce vasogenic cerebral oedema, relieve ICP
Mannitol 20% IV	Osmotherapy for acute ICP crisis
Anti-epileptics (Levetiracetam, Lacosamide, Valproate)	Seizure prevention and control
Analgesics (Paracetamol, NSAIDs, Opioids)	Pain management, headache relief
Antiemetics (Ondansetron, Metoclopramide)	Nausea/vomiting from ICP and chemotherapy
GI protection (PPI/H2 blockers)	Steroid-induced gastropathy prevention
Physiotherapy and rehabilitation	Motor function restoration, fall prevention
Psychological support	Patient and family mental health, grief support
Family counselling	Prognosis communication, advance care planning

Table 5. Supportive Care Framework for Glioblastoma Management

VIII. DISCUSSION

This case encapsulates several critical lessons for clinicians, pharmacists, and healthcare teams managing brain tumour patients.

The Deceptive Nature of GBM Onset. A 75-year-old

woman with no preceding neurological symptoms presented with her first-ever seizure. GBM, despite being the most aggressive primary brain tumour, may present abruptly without a prodromal period. Unlike low-grade gliomas, which may evolve overyears,GBM can achieve sufficient mass and cortical irritation to precipitate a seizure within weeks of clinically detectable growth. First-time seizure in any adult — particularly those above 40–50 years — must be presumed structural until proven otherwise.

Normal Vitals as False Reassurance. The patient's blood pressure, pulse, oxygen saturation, and temperature were all within normal ranges at presentation. This illustrates a critical teaching point: the Cushing's triad (hypertension, bradycardia, irregular respirations) — the classical sign of severe ICP elevation — develops late, representing decompensated herniation. Many GBM patients, especially in earlier stages of mass effect, will maintain physiological homeostasis until herniation is imminent.

MR Spectroscopy in GBM Diagnosis. The finding of an elevated choline peak on MR spectroscopy was pivotal in this case. Choline reflects cell membrane phospholipid turnover and is elevated in rapidly proliferating malignancies. The choline:NAA (N-acetylaspartate) ratio is a reliable biomarker distinguishing high-grade glioma from radiation necrosis, low-grade glioma, and abscess. NAA is a neuronal marker; its reduction reflects neuronal loss and displacement by tumour. Spectroscopy thus adds metabolic information to the structural MRI, improving diagnostic confidence and potentially guiding biopsy targeting.

Dual Anti-Epileptic Therapy and Pharmacological Rationale. The combination of levetiracetam and lacosamide represents a rational pharmacological pairing. Levetiracetam acts via the SV2A synaptic vesicle protein, modulating neurotransmitter release and calcium channel function. Lacosamideenhances slow inactivation of voltage-gated sodium channels — a complementary mechanism reducing neuronal hyperexcitability. Both agents have favourable pharmacokinetic profiles with minimal drug-drug interactions, avoiding the enzyme-inducing effects of phenytoin or carbamazepine which complicate concurrent chemotherapy dosing. High-dose methylprednisolone rapidly reduces vasogenic oedema by downregulating VEGF-mediated blood-brain barrier permeability, providing immediate symptomatic and functional benefit.

Elderly Patients and GBM — A Special Population. The elderly GBM population presents unique clinical challenges. Reduced physiological reserve, age-related cerebral atrophy, concurrent small vessel disease (as evidenced in this case),and comorbid conditions limit the rapeutic options. The chronic tobacco use in this patient represents a carcinogen exposure history that may have contributed to the molecular evolution of her tumour. In patients above 70 years, hypofractionated radiotherapy and consideration of MGMT methylation status (to guide chemotherapy decision) are standard practice per EANO/ESMO guidelines.

The Human Dimension of Oncological Care. This case carries exceptional emotional weight: the patient was the presenter's grandmother. Her 96-day journey — from apparent health to death — illustrates that behind every case number is a human story, a family in crisis, and a web of relationships irreversibly altered. Family counselling, honest prognostic communication, advance care planning, and psychological support for both patient and care givers are not peripheral to GBM management—they are central to it.

IX. KEY CLINICAL LEARNING POINTS

1. A first-time seizure in any adult demands urgent neuro imaging—never attribute to idiopathic epilepsy without structural exclusion.
2. Normal vital signs donot exclude serious intracranial pathology.ICP can be significantly elevated before Cushing's triad appears.
3. MRI with gadolinium contrast and MR spectroscopy is the gold standard for GBM characterization; peripheral ring enhancement and elevated choline are hallmark features.
4. Midline shift—even modest(4–5mm)—is an emergency warning sign indicating progressive mass effect.
5. Dual anti-epileptic therapy (Levetiracetam+ Lacosamide) and high-dose corticosteroids form the acute pharmacological cornerstone of GBM management.
6. Elderly patients with GBM require modified treatment strategies; supportive and palliative care are equally important as oncological therapy.

7. Family counseling and psychological support are integral—not adjunctive—components of brain tumour care.

Every case in neuro-oncology represents a family and a community. Awareness saves lives.

X. CONCLUSION

Glioblastoma Multiforme remains one of oncology's most formidable challenges — biologically aggressive, therapeutically resistant, and clinically devastating. This review has synthesized the essential clinical knowledge of brain tumour pathophysiology, symptomatology, diagnosis, and management, anchored by a real-life case study that demonstrates the full spectrum of GBM care from emergency presentation to end of life.

The 96-day clinical trajectory of the presented patient — a 75-year-old grandmother — is not merely a statistic. It is a call to heightened awareness: that silent neurological changes, a first seizure, or a subtle personality shift may be the only warning signal before an aggressive intracranial malignancy declares itself. Early recognition, prompt neuroimaging, multidisciplinary management, and compassionate family-centred care represent our best response to this disease.

As the scientific community continues to pursue advances in molecular targeted therapy, immunotherapy, and tumour - treating fields, the clinical pharmacist, the neurologist, the neurosurgeon, and the palliativeCare team must work in concert—guided always by the understanding that every brain matters, and every story counts.

REFERENCES

[1] Stupp R, Mason WP, van den Bent MJ, et al. Radiotherapy plus concomitant and adjuvant temozolomide for glioblastoma.N Engl J Med. 2005;352(10):987–996.

[2] LouisDN, PerryA, WesselingP,etal. The2021WHOClassificationofTumorsoftheCentralNervousSystem: a summary. Neuro Oncol. 2021;23(8):1231–1251.

[3] OstromQT,PriceM,NeffC,etal.CBTRUSStatisticalReport: PrimaryBrainandOtherCentralNervousSystemTumors Diagnosed in the United States in 2015–2019. Neuro Oncol. 2022;24(Suppl 2):v1–v95.

[4] WellerM, vandenBentM, PreusserM, etal.EANOguidelinesonthediagnosisandtreatmentofdiffusegliomasof adulthood. Nat Rev Clin Oncol. 2021;18(3):170–186.

[5] Wick W, Gorlia T, Bendszus M, et al. Lomustine and bevacizumab in progressive glioblastoma. N Engl J Med.2017;377(20):1954–1963.

[6] StuppR, TaillibertS, KannerA, etal. Effectoftumor-treatingfieldsplusmaintenancetemozolomidevsmaintenance temozolomide alone on survival in patients with glioblastoma: a randomized clinical trial. JAMA. 2017;318(23):2306–2316.

[7] HegiME, DiserensAC, GorliaT, etal. MGMTgenesilencingandbenefitfromtemozolomideinglioblastoma.NEnglJ Med. 2005;352(10):997–1003.

[8] MootsPL, MaciunasRJ, EisertDR, etal. Thecourseofseizuredisordersinpatientswithmalignantgliomas.Arch Neurol.1995;52(7):717–724.

[9] Gorlia T, van den Bent MJ, Hegi ME, et al. Nomograms for predicting survival of patients with newly diagnosed glioblastoma: prognosticfactoranalysisofEORTCandNCICtrial 26981-22981/CE.3.LancetOncol.2008;9(1):29–

[10] Felistia Y, Wen PY. Molecular Profiling and Targeted Therapies in Gliomas. Curr Neurol Neurosci Rep. 2023; 23:627–636.

[11] K Urbańska, J Sokołowska, M Szmidt… - Contemporary Oncology …, 2014 - termedia.pl

[12] F Hanif, K Muzaffar, K Perveen… - Asian Pacific journal …, 2017 - pmc.ncbi.nlm.nih.gov

[13] C Alifieris, DT Trafalis - Pharmacology & therapeutics, 2015 – Elsevier

[14] C Adamson, OO Kanu, AI Mehta, C Di… - Expert opinion on …, 2009 - Taylor & Francis

[15] DW Parsons, S Jones, X Zhang, JCH Lin, RJ Leary… - science, 2008 - science.org