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Risk of Neurological Decline in Patients With Temporal Lobe Brain Masses

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Abstract. *Aim: The objective of this study was to assess which clinical and radiographic findings may be associated with neurological decline in patients with temporal lobe mass lesions. Patients and Methods: This represents a retrospective cohort study. Neurological decline was defined as a decline in Glasgow Coma Scale of 2 or more or new anisocoria. Adult patients aged 18 to 89 years with isolated temporal lobe, intra-axial, contrast-enhancing masses diagnosed between 1/1/2010 and 12/31/2020 were included. Clinical and radiographic findings were collected for each patient. Linear regression analysis was used to identify findings predictive of neurological decline. Patients with neurological decline were compared to stable patients to identify factors that may increase risk for neurological decline. Results: A total of 71 patients met the inclusion criteria. Four out of the 71 patients experienced neurological decline, representing an incidence of 6%. Linear regression analysis identified only radiographic transtentorial herniation as a predictor of neurological decline (β=0.26, p=0.03). A midline shift greater than 5 mm (100% vs. 40%; odds ratio=1.12, 95% confidence interval=1.00-1.32; p=0.05) and radiographic transtentorial herniation (75% vs. 18%; odds ratio=32.12, 95% confidence interval=3.91-264.18; p=0.03) were significantly more prevalent in patients with neurological decline and were associated with an increased risk of neurological decline. Conclusion: Radiographic transtentorial herniation and a midline shift greater than 5 mm may be useful findings to suggest an increased risk of neurological decline in patients with masses of the temporal lobe. This knowledge may be useful to neurosurgeons and physicians in other specialties to best care for this patient population.*

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Brain masses of the temporal lobe present unique management challenges (1). While clinical presentation may be variable, the mass effect from large tumor size, vasogenic edema, and other factors such as tumor hemorrhage may increase the risk of rapid neurological decline (2-4). The temporal lobe resides at the floor of the middle fossa, the base of the right and left supratentorial compartments. Lateral displacement of brain contents can lead to neurological deficits through mass effect on adjacent brain structures. Displacement of the mesial temporal structures over the tentorial notch with resulting mass effect on the brainstem can result in a neurological emergency, namely transtentorial herniation (3, 5-7). Timely treatment to prevent neurological deterioration is critically important for patient outcomes (2, 4-6).

There is currently a lack of defined, evidence-based risk factors for neurological decline in patients with masses of the temporal lobe. Identification of these factors may assist neurosurgeons in safe operative planning and other specialties in determining the appropriate urgency of neurosurgical referral or consultation. The objective of this study was to assess which clinical and radiographic findings may be associated with neurological decline in patients with temporal lobe mass lesions.

Patients and Methods

Study design. This represents a retrospective cohort observational study at one tertiary care center. Patients were identified using the neurosurgery department internal database. Data was collected through electronic health record review. The study protocol was approved by the Institutional Review Board (approved 2/6/2021, approval number 6077, exempt status).

Adult patients (age 18 to 89 years) with an isolated intra-axial mass of the temporal lobe, diagnosed between January 1, 2010 and December 31, 2020, were included in this study. Masses with

Table I. *Demographics of the patient cohort (n=71).*

Variable	Value
Age, years	
Range	31-88
Mean±SD	60±14
Sex, n (%)	
Female	42 (58)
Male	30 (42)
CCI, n (%)	
Range	2-12
Mean±SD	6 (3)
Symptom duration, n (%)	
<1 Week	26 (36)
<1 Month	21 (29)
>1 Month	25 (35)
GCS at presentation, n (%)	
Range	8-15
Mean±SD	15 (1)
Histopathology, n (%)	
Metastatic tumor	18 (25)
Glioblastoma	43 (60)
Diffuse astrocytoma	6 (8)
Cavernoma	1 (1)
CNS lymphoma	2 (3)
Pilocytic astrocytoma	1 (1)
Pleomorphic xanthoastrocytoma	1 (1)
Corticosteroid therapy, n (%)	
Yes	64 (89)
Patient management, n (%)	
No surgical intervention	10 (14%)
Stereotactic biopsy	2 (3%)
Surgical resection	60 (83%)

CCI: Charlson Comorbidity Index; GCS: Glasgow Coma Scale; SD: standard deviation.

Table II. *Results of linear regression analysis with neurological decline* as the dependent variable.*

Independent variable	β	*p*-Value
Clinical findings		
Age	–0.02	0.89
Sex	0.10	0.40
CCI	0.00	0.10
Symptom duration		
<1 Week	0.14	0.26
<1 Month	0.07	0.59
≥1 Month	–0.20	0.09
GCS at presentation	–0.10	0.40
Histopathologic diagnosis	–0.70	0.40
Corticosteroid use	0.10	0.42
Radiographic imaging findings		
Tumor laterality	0.05	0.70
Greatest tumor diameter	0.13	0.29
Tumor size	0.12	0.32
Mean MLS	0.21	0.07
MLS		
<5 mm	0.22	0.07
≥5 mm		
Radiographic transtentorial herniation	0.26	**0.03**
Ambient cistern effacement	0.06	0.65
Sulcal effacement	0.02	0.85
Trapped temporal horn	0.00	0.97
Tumor hemorrhage	0.01	0.91
Vasogenic edema	0.01	0.96
Obstructive hydrocephalus	0.14	0.24
Cystic tumor	0.10	0.43

β: Standardized coefficient; CCI: Charlson Comorbidity Index; GCS: Glasgow Coma Scale; MLS: midline shift. Statistically significant p-values are shown in bold. *Decline in overall GCS score of 2 or more or new anisocoria.

extension into adjacent lobes, the diencephalon, or the brainstem were excluded to minimize heterogeneity. Included masses were gadolinium contrast-enhancing on T1-weighted magnetic resonance imaging (MRI). Patients that did not have an available MRI with and without gadolinium contrast prior to neurological decline or neurosurgical intervention were excluded.

Data collection. Clinical findings were collected for the patient cohort. These included: Patient age, sex, Charlson Comorbidity Index (CCI), symptom duration, Glasgow Coma Scale (GCS) at presentation, histopathological diagnosis, corticosteroid therapy, and patient management. CCI was chosen to serve as a validated objective measure of patient overall health and medical comorbidities (8). Histopathology was described according to the 2021 World Health Organization Classification of Tumors of the Central Nervous System (9). Corticosteroid therapy for all patients was dexamethasone, administered as a 10 mg loading dose followed by 4 mg every 6 hours (4). Patients were started on antiepileptic therapy only if they suffered a seizure event (10). Patient management included neurosurgical resection, stereotactic biopsy, or no neurosurgical intervention.

Radiographic imaging findings were collected for each patient using T1-weighted MRI with gadolinium contrast. Data collected included: Tumor laterality, greatest tumor diameter, tumor size, midline shift (MLS), radiographic transtentorial herniation, ambient cistern effacement, sulcal effacement, trapped temporal horn, tumor hemorrhage, vasogenic edema, obstructive hydrocephalus, and primarily cystic tumor. Greatest tumor diameter and tumor size were measured using the Response Assessment in Neuro-oncology (RANO) criteria for high-grade glioma and brain metastases (11, 12). Radiographic transtentorial herniation was defined as medial displacement of the mesial temporal lobe structures effacing the ambient cistern and displacement of the midbrain from supratentorial mass effect (3). Radiographic findings were identified by a Board-certified attending neuroradiologist and collected from the final imaging study report.

The primary outcome assessed was neurological decline after clinical presentation. Neurological decline was defined as a decline in the GCS overall score of 2 or more or new anisocoria (5, 6, 13-15). A time period of 5 days after clinical presentation was used.

Additional data were collected for patients that suffered neurological decline. These included neurological deficits at presentation, GCS at presentation, time from presentation to decline, clinical details of decline, neurosurgical interventions, histopathology, postoperative neurological deficit, postoperative GCS, and patient survival.

Table III. *Clinical course of patients with neurological decline (n=4).*

Patient	At presentation		Decline		Neurosurgical intervention	Histopathology	Postoperative		Survival, days
	Neurological deficit	GCS	Time from presentation, days	Details			Neurological deficit	GCS	
1*	Cognitive decline	14	1	GCS 8, unresponsive	-	-	-	-	1
2	Expressive aphasia	14	1	GCS 9, global aphasia, obtunded	Emergency surgical resection	Glioblastoma	Worse expressive aphasia, disorientation	12	93
3	Left hemiparesis, lethargy	14	4	GCS 7, unresponsive	Emergency surgical resection	Glioblastoma	Left hemiparesis	15	893
4	None	15	2	GCS 3, anisocoria	Emergency surgical resection	Metastatic tumor	None	15	Alive

GCS: Glasgow Coma Scale. *Patient did not undergo surgery and received best supportive measures based on advanced directives.

Statistical analysis. Descriptive statistics for clinical and radiographic findings were calculated. The range, mean, standard deviation (SD), and percentages were reported as appropriate. Linear regression analysis was used to identify which clinical or radiographic imaging findings may predict neurological decline. Patients who experienced neurological decline were compared to patients who remained neurologically stable using *t*-tests of independent samples, chi-squared analysis, and Fisher exact probability tests as appropriate. Results were considered statistically significant when the resulting *p*-value was less than 0.05. For statistically significant variables in group comparison analysis, odds ratios (OR) were calculated and reported with their associated 95% confidence intervals (95% CI). All statistics were performed using IBM SPSS statistics (Released 2021; IBM SPSS Statistics for Windows, Version 28.0. IBM Corp., Armonk, NY, USA).

Results

Cohort demographics. Patient demographics including patient age, sex, CCI, symptom duration, GCS at presentation, histopathology results, corticosteroid therapy, and patient management are reported in Table I.

Linear regression analysis. Linear regression analysis was completed for each independent clinical and radiographic variable to identify which may predict neurological decline. Radiographic transtentorial herniation was the only variable that predicted neurological decline (β=0.26, p=0.03). CCI (β=0.00, p=0.10), mean MLS (β=0.21, p=0.07), and MLS greater than 5 mm (β=0.22, p=0.07) tended towards being statistically significantly associated with neurological decline. Symptom duration greater than 1 month tended towards predicting against neurological decline (β=–0.20, p=0.09) (Table II).

Comparison between neurologically stable patients and those with neurological decline. Four out of 71 patients experienced neurological decline representing an incidence of 6%. Three patients (75%) were treated with emergency surgical resection and one patient (25%) received best supportive measures with no surgical interventions based on advanced directives. The clinical course of patients with neurological decline can be viewed in Table III.

MLS greater than 5 mm (100% *vs*. 40%, p=0.05) and radiographic transtentorial herniation (75% *vs*. 18%, p=0.03) were significantly more prevalent in patients with neurological decline. Moreover, the mean MLS was significantly greater in these patients (8.5 mm, SD=5 mm) compared to patients that remained neurologically stable (3.4 mm, SD=4 mm) (p=0.01). No significant differences were found between groups for other clinical and radiographic imaging findings (Table IV).

Radiographic transtentorial herniation (OR=32.12, 95% CI=3.91-264.18) and MLS greater than 5 mm (OR=1.12, 95% CI=1.00-1.32) were associated with an increased risk of neurological decline.

Discussion

Masses of the temporal lobe can present unique management challenges (1). Mass effect from tumor size, vasogenic edema, and tumor characteristics can quickly lead to neurological decompensation (4). Expeditious management of patients at increased risk for neurological decline is warranted, however, the objective findings that quantify and predict a patient's risk have not yet been described (2, 4-6).

Table IV. *Comparison of patients with neurological decline* and neurologically stable patients.*

Variable	Neurological status		
	Decline (n=4)	Stable (n=67)	*p*-Value
Clinical findings			
Age, years			
Mean±SD	62 (16)	60 (14)	0.77
Sex			
Male (%)	3 (75)	27 (38)	0.30
Female (%)	1 (25)	40 (56)	
CCI			
Mean±SD	7 (2)	6 (3)	0.45
Symptom duration			
<1 Week	3 (75)	23 (34)	0.20
<1 Month	1 (25)	19 (28)	
≥1 Month	0 (0)	25 (37)	
GCS at presentation			
Mean±SD	14 (1)	15 (1)	0.51
Tumor pathology			
Metastatic tumor	1 (25)	17 (25)	0.99
Glioblastoma	3 (75)	39 (58)	
Diffuse astrocytoma	0 (0)	6 (9)	
Cavernoma	0 (0)	1 (1)	
CNS lymphoma	0 (0)	2 (3)	
Pilocytic astrocytoma	0 (0)	1 (1)	
Pleomorphic xanthoastrocytoma	0 (0)	1 (1)	
Corticosteroid therapy, n (%)			
Yes	4 (100)	59 (88)	>0.99
Radiographic imaging findings			
Tumor laterality			
Left (%)	1 (25)	33 (49)	0.62
Right (%)	3 (75)	34 (51)	
Greatest tumor diameter, mm			
Mean±SD	52 (11)	39 (18)	0.14
Tumor size, mm^2			
Mean±SD	2,056 (916)	1,265 (1010)	0.13
MLS, mm			
Mean±SD	8.5 (5)	3.4 (4)	**0.01**
MLS, n (%)			
<5 mm	0 (0)	40 (60)	**0.05**
≥5 mm	4 (100)	27 (40)	
Radiographic transtentorial herniation, n (%)	3 (75)	12 (18)	**0.03**
Ambient cistern effacement, n (%)	3 (75)	33 (49)	0.61
Sulcal effacement, n (%)	4 (100)	51 (76)	0.57
Trapped temporal horn, n (%)	1 (25)	13 (19)	>0.99
Tumor hemorrhage, n (%)	1 (25)	12 (18)	0.56
Vasogenic edema, n (%)	4 (100)	53 (79)	0.58
Obstructive hydrocephalus, n (%)	1 (25)	4 (6)	0.26
Cystic tumor, n (%)	1 (25)	6 (9)	0.35

CCI: Charlson Comorbidity Index; GCS: Glasgow Coma Scale; MLS: midline shift; SD: standard deviation. *Defined as a decline in overall GCS score of 2 or more or decline in motor score of 1 or more. Statistically significant *p*-values are shown in bold.

In this study, we attempted to provide evidence for clinical and radiographic findings that may increase this risk.

The identification of radiographic transtentorial herniation and MLS greater than 5 mm appears to have the strongest relationship with impending neurological decline. Radiographic transtentorial herniation predicted neurological decline in univariate analysis (β=0.26, p=0.03) and was significantly more prevalent in patients with decline in

comparison to those that remained stable (75% *vs*. 18%, OR=32.12, 95% CI=3.91-264.18, p=0.03). MLS greater than 5 mm was also more prevalent in patients with decline (100% *vs*. 40%, OR=1.12, 95% CI=1.00-1.32, p=0.05). Patients with neurological decline had a higher mean MLS than those that remained stable (8.5 *vs*. 3.4 mm, p=0.01).

Increased risk for neurological decline with radiographic transtentorial herniation and MLS greater than 5 mm is not surprising. The presence of these radiographic findings suggests extensive mass effect and displacement of neurological structures (3). The objective identification of these variables, however, may be clinically useful for neurosurgeons and other specialists to appropriately triage and manage this patient population. Patients with these radiographic findings may benefit from timely surgical treatment or urgent referral by non-neurosurgeons.

In our cohort, patients who neurologically declined presented with favorable neurological examinations (mean GCS=14.3, range=14-15) with an average time from presentation to decline of 2 days (range=1-4 days). Limited conclusions can be drawn from such a small cohort; however, these findings do support the concept of expeditious surgical management of patients with high-risk imaging findings, even with favorable neurological examinations at presentation. Radiographic transtentorial herniation and MLS greater than 5 mm may represent findings that suggest an elevated risk of neurological decline.

Limitations. Limitations in our study design and findings are worth discussion. The small sample size limits conclusions that can be drawn from the study as important findings may be missed if insufficient power is present. This is especially important when the outcome of interest is rare. All data was collected through retrospective electronic health record review and therefore subject to limitations in documentation and data retrieval. The retrospective study design limits the strength of conclusions that can be drawn from the study due to an inferior level of evidence, the potential for recall bias, misclassification bias, and confounding, and the inability to determine causation. Tumor size was measured using the RANO criteria and not using computerized volumetric analysis. The strict inclusion criteria of intra-axial, contrast-enhancing, isolated temporal lobe masses may also have introduced sampling bias.

Future directions. Pooling patient data from multiple centers may provide a larger sample for data analysis to draw stronger conclusions on which factors may increase risk for neurological decline. Identification of more factors from a larger patient data set may allow for the creation of a grading or scoring system that correlates with risk of decompensation to aid in surgical decision-making. An analysis including masses of the frontal, parietal, and occipital lobes may be useful, as temporal lobe masses represent only a proportion of brain masses. Following-up a cohort of these patients over a longer period of time may be useful to understand how pre-operative neurological decline is correlated with patient outcome.

Conflicts of Interest

The Authors report no conflicts of interest of any form.

Authors' Contributions

Jared Sweeney: Study design, data collection, data analysis, article drafting and review. Melanie Bondoc: Data collection, data analysis, article drafting. Sruti Bandlamuri: Data collection, article drafting and review. Matthew Holdaway: Data collection. Pouya Entezami: Study design, article review. Michael O'Brien: Study design, article review. Matthew Adamo: Study design, article review, project supervision.

References

1 Alentorn A, Hoang-Xuan K and Mikkelsen T: Presenting signs and symptoms in brain tumors. Handb Clin Neurol *134*: 19-26, 2016. PMID: 26948346. DOI: 10.1016/B978-0-12-802997-8.00002-5

2 Suarez-Meade P, Marenco-Hillembrand L and Sherman WJ: Neuro-oncologic emergencies. Curr Oncol Rep *24(8)*: 975-984, 2022. PMID: 35353348. DOI: 10.1007/s11912-022-01259-3

3 Riveros Gilardi B, Muñoz López JI, Hernández Villegas AC, Garay Mora JA, Rico Rodríguez OC, Chávez Appendini R, De la Mora Malváez M and Higuera Calleja JA: Types of cerebral herniation and their imaging features. Radiographics *39(6)*: 1598-1610, 2019. PMID: 31589570. DOI: 10.1148/rg.2019190018

4 Esquenazi Y, Lo VP and Lee K: Critical care management of cerebral edema in brain tumors. J Intensive Care Med *32(1)*: 15-24, 2017. PMID: 26647408. DOI: 10.1177/0885066615619618

5 Cadena R, Shoykhet M and Ratcliff JJ: Emergency neurological life support: Intracranial hypertension and herniation. Neurocrit Care *27(Suppl 1)*: 82-88, 2017. PMID: 28913634. DOI: 10.1007/s12028-017-0454-z

6 Stevens RD, Shoykhet M and Cadena R: Emergency neurological life support: Intracranial hypertension and herniation. Neurocrit Care *23(Suppl 2)*: S76-S82, 2015. PMID: 26438459. DOI: 10.1007/s12028-015-0168-z

7 Adler DE and Milhorat TH: The tentorial notch: anatomical variation, morphometric analysis, and classification in 100 human autopsy cases. J Neurosurg *96(6)*: 1103-1112, 2002. PMID: 12066913. DOI: 10.3171/jns.2002.96.6.1103

8 Brusselaers N and Lagergren J: The Charlson Comorbidity index in registry-based research. Methods Inf Med *56(5)*: 401-406, 2017. PMID: 29582935. DOI: 10.3414/ME17-01-0051

9 Louis DN, Perry A, Wesseling P, Brat DJ, Cree IA, Figarella-Branger D, Hawkins C, Ng HK, Pfister SM, Reifenberger G, Soffietti R, von Deimling A and Ellison DW: The 2021 WHO Classification of Tumors of the Central Nervous System: a summary. Neuro Oncol *23(8)*: 1231-1251, 2021. PMID: 34185076. DOI: 10.1093/neuonc/noab106

10 Walbert T, Harrison RA, Schiff D, Avila EK, Chen M, Kandula P, Lee JW, Le Rhun E, Stevens GHJ, Vogelbaum MA, Wick W, Weller M, Wen PY and Gerstner ER: SNO and EANO practice guideline update: Anticonvulsant prophylaxis in patients with newly diagnosed brain tumors. Neuro Oncol *23(11)*: 1835-1844, 2021. PMID: 34174071. DOI: 10.1093/neuonc/noab152

11 Yang D: Standardized MRI assessment of high-grade glioma response: a review of the essential elements and pitfalls of the RANO criteria. Neurooncol Pract *3(1)*: 59-67, 2016. PMID: 31579522. DOI: 10.1093/nop/npv023

12 Lin NU, Lee EQ, Aoyama H, Barani IJ, Barboriak DP, Baumert BG, Bendszus M, Brown PD, Camidge DR, Chang SM, Dancey J, de Vries EG, Gaspar LE, Harris GJ, Hodi FS, Kalkanis SN, Linskey ME, Macdonald DR, Margolin K, Mehta MP, Schiff D, Soffietti R, Suh JH, van den Bent MJ, Vogelbaum MA, Wen PY and Response Assessment in Neuro-Oncology (RANO) group: Response assessment criteria for brain metastases: proposal from the RANO group. Lancet Oncol *16(6)*: e270-e278, 2015. PMID: 26065612. DOI: 10.1016/S1470-2045(15)70057-4

13 Nyancho D, Atem FD, Venkatachalam AM, Barnes A, Hill M, Traylor JI, Stutzman SE, Bedros N, Aiyagari V and Aoun SG: Anisocoria correlates with injury severity and outcomes after blunt traumatic brain injury. J Neurosci Nurs *53(6)*: 251-255, 2021. PMID: 34620803. DOI: 10.1097/JNN.0000000000000613

14 Lord AS, Gilmore E, Choi HA, Mayer SA and VISTA-ICH Collaboration: Time course and predictors of neurological deterioration after intracerebral hemorrhage. Stroke *46(3)*: 647-652, 2015. PMID: 25657190. DOI: 10.1161/STROKEAHA.114.007704

15 Mehta R and Chinthapalli K: Glasgow Coma Scale explained. BMJ *365*: l1296, 2019. PMID: 31048343. DOI: 10.1136/bmj.l1296

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