Mean Oedema Index in Intracranial Supratentorial Meningiomas: Influence of Location

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ABSTRACT

Background: Peritumoural brain oedema (PTBOe) is a common feature of intracranial supratentorial meningiomas, potentially complicating surgical management and affecting prognosis. The influence of tumour location on the severity of PTBOe remains controversial. This study aimed to evaluate the mean oedema index and its relationship with tumour location in patients with supratentorial meningiomas. **Methods & Materials:** An observational cross-sectional study was conducted on 34 patients with WHO Grade I supratentorial meningiomas who underwent surgical resection. Clinical, neurological, and radiological data were collected, and tumour and oedema volumes were measured from CT scans to calculate the oedema index. Tumours were classified into six locations: frontobasal, temporobasal, convexity, falcine and parasagittal, sphenoid wing, and suprasellar. One-way ANOVA was used to compare mean oedema indices among different tumour locations. **Results:** The mean age of patients was 38.5 ± 14.2 years, with females comprising 58.8%. Headache (97.1%), vomiting (58.8%), and convulsions (58.8%) were the most common presenting complaints. Cranial nerve involvement was observed in 70.6% of patients. Convexity meningiomas were most frequent (44.1%), followed by frontobasal (14.7%) and temporobasal (11.8%) locations. Mean oedema indices were highest for temporobasal (3.29) and frontobasal (3.18) meningiomas and lowest for sphenoid wing meningiomas (2.23). One-way ANOVA revealed no statistically significant difference in mean oedema index among tumour locations (F = 0.50, P = 0.774). **Conclusion:** The severity of peritumoural brain oedema in supratentorial meningiomas was not significantly influenced by tumour location. High-resolution CT imaging is recommended for accurate assessment of tumour and oedema volumes to guide preoperative planning and symptomatic management.

Keywords: *Supratentorial meningioma, peritumoural brain oedema, oedema index, tumour location, CT scan, neurological outcome.*

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INTRODUCTION

Meningioma, a term introduced by Harvey Cushing, refers to a usually benign tumour of the meninges, accounting for 15% of all intracranial tumours, most commonly arising in the supratentorial compartment [1]. Despite their extra-axial origin, approximately 60% of meningiomas are associated with peritumoural brain oedema (PTBOe) [2,3]. PTBOe is clinically significant, as it can complicate surgical resection, increase intracranial pressure, and worsen prognosis [4].

The pathogenesis of PTBOe remains incompletely understood. Proposed mechanisms include ischemia from tumour compression [5], venous stasis [4], tumour-secreted edemogenic factors such as prostaglandins [6,7], and a hydrodynamic process involving leakage from tumour vasculature [4]. Other contributing factors may include tumour size, histology, and brain–tumour interface changes such as adhesion or invasion [8,9]. VEGF expression has also been implicated in PTBOe formation [4].

Tumour location strongly influences oedema development. Temporobasal and frontobasal meningiomas exhibit the highest oedema incidence and mean oedema index, significantly greater than convexity, falcine, or sphenoid wing meningiomas [10]. Understanding the relationship between tumour location and oedema index is therefore essential for predicting surgical risk and patient outcomes. Despite extensive research, the factors influencing the severity of PTBOe, particularly the role of tumour location, remain incompletely defined. Quantifying the mean oedema index in relation to supratentorial meningioma location may improve preoperative planning and risk stratification. Therefore, this study aims to evaluate the mean oedema index in intracranial supratentorial meningiomas and assess the influence of tumour location on peritumoural oedema.

METHODS & MATERIALS

Study Design and Setting: This was an observational cross-sectional study conducted in the Department of Neurosurgery, Bangladesh Medical University (BMU), Dhaka Medical College Hospital, and selected private hospitals. The study period was from 1 May 2024 to 31 October 2025.

Study Population and Sampling: Patients with supratentorial meningiomas confirmed on CT scan, who underwent surgical resection with histopathological confirmation of WHO Grade I meningioma, were included. Exclusion criteria were posterior fossa, recurrent, multiple, intraventricular meningiomas, and WHO Grade II or III tumours. A non-probability convenience sampling method was used.

Sample Size: The sample size was calculated using the formula for comparing means [11], considering expected differences in oedema indices between tumour locations. The required sample size was estimated as 55 patients.

Data Collection: A detailed clinical history and neurological examination were performed for all patients. Preoperative CT scans were reviewed to measure the maximum perpendicular diameters of both tumour and peritumoural oedema in axial sections (a, b), and the coronal diameter (c) was approximated using the number of slices multiplied by slice thickness. Tumour and oedema volumes were calculated using the ellipsoid formula, and the oedema index (OeI) was determined as the ratio of oedema volume to tumour volume [10,12,13]. Operative findings and histopathology reports were recorded. Data were collected using a standardized data collection sheet.

Ethical Considerations: Ethical approval was obtained from the Department of Neurosurgery and the central ethical committee, BMU. Written informed consent was obtained from all patients or their attendants, with assurance of confidentiality and the purpose of study explained.

Statistical Analysis: Data were analyzed using SPSS version 16. Continuous variables were expressed as mean ± SD. One-way ANOVA was used to compare mean oedema indices among different tumour locations. Statistical significance was set at $P < 0.05$.

RESULTS

A total of 34 patients with supratentorial meningiomas were included in the study. The demographic, clinical, neurological, and radiological characteristics of the patients, as well as tumour location and associated peritumoural oedema, are presented below.

Table I shows the demographic profile of the patients with a mean age of 38.5 years (range: 18–91 years). The majority of patients (38.2%) were in the 41–50 years age group. Female patients predominated, accounting for 58.8% of the sample, with a female-to-male ratio of 1.4:1.

Table I
Demographic Distribution of Study Subjects (n = 34).

Characteristic	Category	Frequency	Percentage (%)
Age (years)	11–20	2	5.9
	21–30	8	23.5
	31–40	8	23.5
	41–50	13	38.2
	51–60	2	5.9
	>60	1	2.9
Sex	Male	14	41.2
	Female	20	58.8

Table II shows percentage of presenting complaints that occur in meningioma patients. Headache and vomiting were found in 33(97.1%) and 20(58.8%) number of patients respectively, convulsion in 20 (58.8%) number of patients. In this frequency table, the respondents have multiple responses, e.g. if one patient had headache he may also had vomiting or history of Unconsciousness.

Table II
Distribution of the respondents by presenting complaints (multiple responses).

Complaints	Frequency	Percentage (%)
Headache	33	97.1
Vomiting	20	58.8
History of Unconsciousness	8	23.5
Convulsion	20	58.8
Blurring and dimness of vision	14	41.2
Limb Weakness	11	32.4

The neurological assessment of the 34 patients revealed that higher mental functions were affected in 23.5% of cases, indicating mild cognitive or speech involvement in a subset of patients. The optic (2nd) cranial nerve was the most commonly affected, with 70.6% showing impairment, reflecting the frequent involvement of visual pathways in supratentorial meningiomas. Gait disturbances and motor deficits were observed in 17.6% and 23.5% of patients, respectively, while sensory deficits were relatively uncommon (5.9%). Fundoscopy findings demonstrated that only one-third of patients had normal optic discs, whereas papilloedema and optic atrophy were present in 29.4% and 35.3%, respectively, suggesting raised intracranial pressure or chronic optic nerve compromise in a substantial proportion of patients (*Table III*).

Table III
Neurological and Fundoscopy Findings of Study Subjects (n = 34).

Findings	Normal, n (%)	Impaired, n (%)	Total, n (%)
Higher Mental Functions including Speech	26 (76.5)	8 (23.5)	34 (100)
Cranial Nerve (2nd / Optic)	10 (29.4)	24 (70.6)	34 (100)
Gait	28 (82.4)	6 (17.6)	34 (100)
Motor System	26 (76.5)	8 (23.5)	34 (100)
Sensory System	32 (94.1)	2 (5.9)	34 (100)
Fundoscopy	12 (35.3)	–	34 (100)
Papilloedema	–	10 (29.4)	34 (100)
Optic Atrophy	–	12 (35.3)	34 (100)

Table IV shows location of meningiomas. Location wise the meningiomas have been divided in six groups. Convexity shows highest frequency of 15(44.1%), frontobasal and temporobasal shows 5(14.7%) and 4(11.8%) respectively, falcine and parasagittal shows 3(8.8%), sphenoid wing shows 3(8.8%) and suprasellar shows 4(11.8%) out of 34 number of patients.

Table IV
Distribution of the respondents by location of the tumour.

Location	Frequency (N)	Percentage (%)
Frontobasal	5	14.7
Temporobasal	4	11.8
Convexity (frontal, parietal, temporal, occipital)	15	44.1
Falcine and parasagittal	3	8.8
Sphenoid wing	3	8.8
Suprasellar	4	11.8
Total	34	100

Table V shows Mean Oedema Index of meningiomas in various locations according to frequencies. Frontobasal and Temporobasal meningiomas are with 3.18 and 3.60 of Mean Oedema Index respectively; Convexity meningiomas are with 2.47 of mean Oedema Index, Falcine and Parasagittal meningiomas are with 3.12 of mean Oedema Index and Suprasellar meningiomas are with 2.44 of mean Oedema Index.

Table V
Mean Oedema Index in various locations.

Tumour Location	Frequency	Mean Oedema Index	Standard Deviation
Frontobasal	5	3.18	2.01
Temporobasal	4	3.29	2.34
Convexity	15	2.47	1.04
Falcine and parasagittal	3	3.12	0.88
Sphenoid wing	3	2.23	1.00
Suprasellar	4	2.44	0.89
Total	34	2.76	1.36

The one-way ANOVA analysis showed no statistically significant difference in mean oedema index among the different tumour locations ($F = 0.50$, $P = 0.774$) (*Table VI*). This suggests that, in this cohort, tumour location did not significantly influence the severity of peritumoural brain oedema.

Table VI
Comparison of Mean Oedema Index Across Different Tumour Locations Using One-Way ANOVA ($n = 34$).

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F	P-value
Between Locations	4.81	5	0.96		
Within Location	53.94	28	1.92	.500	.774
Total	58.76	33			

DISCUSSION

Meningiomas are among the most common intracranial tumours, and their propensity to produce peritumoural brain oedema (PTBOe) varies considerably among cases [14]. The mechanisms underlying PTBOe in meningiomas remain multifactorial and incompletely understood, with contributions from tumour size, histology, brain–tumour interface characteristics, and secretory activity [13]. Identifying which factor predominates in individual cases is often challenging. The influence of tumour location on the development of PTBOe remains controversial. While some studies suggest certain locations are associated with higher oedema incidence, the evidence is inconsistent, and the specific locations identified vary across studies [4]. PTBOe can have significant clinical implications, including reducing the radicality of tumour resection, complicating surgery in eloquent brain regions, and potentially increasing recurrence rates [4].

In the present study, the mean age of patients was 38.5 years, consistent with previous reports from the subcontinent indicating peak incidence in the fourth decade [15]. Females predominated, comprising 58.8% of the cohort, with a female-to-male ratio of 1.4:1, similar to other studies reporting ratios around 1.5:1 [16]. According to complaints- Headache (97.1%), vomiting (58.8%), and convulsions (58.8%) were the most common presenting symptoms, followed by blurring of vision (41.2%), limb weakness (32.4%), and loss of consciousness (23.5%). These findings are comparable to previously published data, which reported headache in 66.7%, epilepsy in 28.5%, and motor-sensory deficits in 30% of patients [17].

Neurological assessment revealed cranial nerve involvement in 70.6% of patients, higher mental function and speech impairment in 23.5%, motor deficits in 23.5%, gait disturbances in 17.6%, and sensory deficits in 5.9%. Fundoscopy showed papilloedema in 29.4%, optic atrophy in 35.3%, and normal findings in 35.3% of patients, indicating significant optic pathway involvement in a substantial proportion of cases. Regarding tumour location, convexity meningiomas were most frequent (44.1%) with a mean oedema index of 2.47. Frontobasal and temporobasal meningiomas had mean oedema indices of 3.18 and 3.29, respectively, while falcine, sphenoid wing, and suprasellar meningiomas showed indices of 3.12, 2.23, and 2.44, respectively. Although some studies report higher oedema indices in frontobasal and temporobasal locations [10], our analysis using one-way ANOVA revealed no statistically significant difference in oedema index among the six tumour location groups ($F = 0.50$, $p = 0.774$). These findings indicate that, in this cohort, PTBOe does not significantly vary with tumour location, consistent with prior studies reporting no correlation between location and PTBOe [12,18].

Overall, the study confirms that while PTBOe is common in supratentorial meningiomas and can significantly influence clinical management, its severity is not reliably predicted by tumour location alone.

CONCLUSION

In this study of 34 patients with intracranial supratentorial meningiomas, tumour locations were classified as frontobasal, temporobasal, convexity, falcine and parasagittal, sphenoid wing, and suprasellar. Analysis of the mean oedema index showed no significant association between tumour location and the severity of peritumoural brain oedema, indicating that oedema does not vary significantly with tumour location. The study was conducted over a relatively short duration, and the sample size was limited, which may affect the generalizability of the findings. High-resolution, multi-slice CT scans should be utilized for accurate assessment of tumour and oedema volumes. Patients suspected of having brain tumours should undergo prompt contrast-enhanced CT imaging and receive appropriate symptomatic management for peritumoural oedema, even if definitive tumour treatment is delayed.

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