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ORIGINAL ARTICLE

# Predictive value of brain edema in preoperative computerized tomography scanning on the recurrence of meningioma

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**KEYWORDS**

Meningioma;
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**Abstract** *Introduction:* Meningioma is a common benign intracranial tumor. The most common histological subtypes are the transitional and mesothelial subtypes. It can be cured by adequate excision, which is mostly measured by the Simpson grading system. Meningioma can have a peritumoral edema seen in the preoperative computerized tomography as well as in magnetic resonance imaging. It is caused by the release of vasogenic factors that causes leak of fluid from the blood vessels into the brain parenchyma. Recurrence of meningioma has been linked to the presence of preoperative peritumoral brain edema.

*Aim:* The aim of this study is to predict the possibility of meningioma recurrence based on the extent of brain edema in the preoperative computerized scanning of the brain.

*Methods:* Twenty five patients with supratentorial meningioma were retrospectively studied for the relationship between preoperative peritumoral brain edema as measured by the brain edema index and the recurrence of meningioma.

*Results:* The age of the patients ranged from 26 to 69 years. Males and females had almost equal percentages. Most of the cases recurred within a period from 3 years to less than 6 years; while the least recurrence occurred within one year of the surgery. Most of the cases of recurrent meningioma had high brain edema index. The higher the brain edema index, the less average years required for recurrence. The higher the preoperative brain edema index, the higher the possibility of postoperative complications. Tumors at a maximum diameter of three to less than six cm represented the majority of cases. Peritumoral brain edema was present in all cases in sphenoid ridge and parasagittal site.

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*Conclusion:* Preoperative brain edema as measured by brain edema index on the preoperative brain computerized tomography scan had an important impact on the postoperative complication rate as well as on the incidence of tumor recurrence.



## 1. Introduction

Meningioma is the most common benign intracranial tumor.[1] It is an extra-axial tumor that arises from the arachnoid cap cells. It has different locations including parasagittal, olfactory groove, convexity, falcine and posterior fossa locations.[2] Histologically, the most common types are the transitional and mesothelial subtypes. Other histological subtypes are the angiomatous, chordoid and anaplastic.[3] According to the WHO classification, meningioma can be of type I, which is the benign form, type II usually referred to as the atypical meningioma and type III, which is the malignant meningioma.[4] Meningioma is mostly a benign tumor that can be cured completely with surgical resection. The extent of surgical resection is classified according to the Simpson grading system.[5]

Meningioma recurs in about 20–30% of cases.[6] Studying factors that cause tumor recurrence is important because meningioma can be cured with the proper surgical intervention. Factors that determine recurrence of meningioma include the extent of tumor resection according to the Simpson grading system; which is the most important factor, histology of the tumor, location of meningioma, age, gender, signal intensity in the T2-weighted image in the preoperative MRI, vascularity of the tumor, the shape of the tumor surface, the arachnoid plane between the tumor and the brain surface as well as the presence of preoperative peritumoral brain edema.[7–9]

Peritumoral brain edema was found to be present in almost 60% of supratentorial meningioma cases. Studies were done to determine factors that cause brain edema in meningioma.[10–14] The pathophysiology of development of peritumoral brain edema was related to the secretion of vascular endothelial growth factor by the tumor into the adjacent parenchyma of the brain causing vasogenic brain edema. Also the presence of cortical-pial blood supply of the tumor was related to the presence of brain edema.[15–17,1]

Studying the extent of preoperative peritumoral brain edema (PTBE) in meningioma is important since brain edema was found to have a correlation with tumor recurrence.[3,5,7,10] In this study, we tried to find the relationship between the preoperative PTBE and the incidence of tumor recurrence by retrospectively studying cases of meningioma that recurred during the follow-up period.

## 2. Aim of the study

The aim of this study was to detect any correlation between the presence of preoperative brain edema in supratentorial meningioma and the incidence of recurrence of meningioma.

## 3. Materials and methods

This was a retrospective study where data were collected from the patients' archives. This study included 25 patients diagnosed with supratentorial brain meningioma. Any age and both sexes were included in the study.

### *3.1. All patients were submitted to the following*

#### *3.1.1. Preoperatively*

Complete history taking.
Complete general and neurological examination.

Investigations; laboratory and radiological in the form of computerized tomography scanning and magnetic resonance imaging of the brain both with and without contrast.

Preoperative computerized tomography scan was used to determine the extent of peritumoral brain edema using the brain edema index. The brain edema index was calculated by dividing the diameter of the parenchymal edema at the axial cut where the maximal tumor diameter was present by the maximal tumor diameter.

Patients who had their meningioma invading and obstructing the draining veins or sinuses radiologically or observed during surgery were excluded from the study to avoid the confusion whether the brain edema was caused by vascular outflow obstruction or by tumor cells invading the brain parenchyma.

Intraoperatively, patients had craniotomy to remove the meningioma totally. No significant vascular injury occurred in the study cases intraoperatively.

Postoperatively, biopsy was sent for histopathological analysis and patients were followed-up clinically for up to five years with follow-up computerized scanning of the brain with contrast every six -months.

The confidentiality of patients' data was kept.

Statistical analysis: Numbers and percentages were used to describe the results.

## 4. Results

The age of the patients ranged from 26 to 69 years. The age range from 40 to less than 60 years represented the majority of patients. This is shown in Table 1.

As regards the gender of patients, males and females were almost equal as shown in Table 2.

**Table 1** The age category of patients under study.

| Age category | Number of cases | Percentage |
|---|---|---|
| 20 to less than 40 | 5 | 20 |
| 40 to less than 60 | 18 | 72 |
| 60 and more | 2 | 8 |
| Total | 25 | |

**Table 2** The gender of patients under study.

| Gender | Number of cases | Percentage |
|---|---|---|
| Male | 11 | 44 |
| Female | 14 | 56 |
| Total | 25 | |

**Table 3** The number of years since surgery till recurrence in patients under study.

| Number of years since surgery till recurrence | Number of cases | Percentage |
|---|---|---|
| Less than 1 year | 3 | 12 |
| 1 year to less than 3 years | 5 | 20 |
| 3 years to less than 6 years | 13 | 52 |
| 6 years and more | 4 | 16 |
| Total | 25 | |

**Table 4** The brain edema index in patients.

| Brain edema index | Number of cases | Percentage |
|---|---|---|
| Less than 1 | 6 | 24 |
| 1 to less than 2 | 8 | 32 |
| 2 and more | 11 | 44 |
| Total | 25 | |

**Table 5** The relationship between the preoperative brain edema index and the average years since surgery to recurrence.

| Brain edema index | Average years since surgery to recurrence (years) |
|---|---|
| Less than 1 | 5.5 |
| 1 to less than 2 | 3.2 |
| 2 and more | 1.1 |

Most of the cases (52%) recurred within a period from 3 years to less than 6 years after the surgery; while the least recurrence occurred within one year of the surgery (12%). This is shown in Table 3

Most of cases of recurrent meningioma had a high preoperative brain edema index as shown in Table 4.

The higher the brain edema index, the less average years required for recurrence as shown in Table 5.

The higher the preoperative brain edema index, the higher the possibility of postoperative complications as shown in Table 6.

Postoperative weakness (71.4%) followed by transient deterioration of consciousness (50%) were the most common postoperative complications as shown in Table 7.

Tumors at a maximum diameter of three to less than six cm represented the majority of cases and it was found that the larger the tumor size, the higher the incidence of peritumoral brain edema as shown in Table 8.

**Table 6** The relationship between the preoperative brain edema index and the number of patients with postoperative complications.

| Brain edema index | Number of patients with post-operative complications | Percentage |
|---|---|---|
| Less than 1 | 2 | 33 |
| 1 to less than 2 | 4 | 50 |
| 2 and more | 8 | 73 |

**Table 7** The most common postoperative complications reported in patients under study.

| Postoperative complications | Number of cases | Percentage |
|---|---|---|
| Weakness | 10 | 71.4 |
| Transient deterioration of consciousness | 7 | 50 |
| Seizures | 4 | 29 |

**Table 8** The relationship between the maximum diameter of the tumor and the surrounding brain edema.

| Maximum diameter of the tumor | Cases | | Number of cases with surrounding brain edema | |
|---|---|---|---|---|
| | No. | % | No. | % |
| 3 cm and less | 5 | 20 | 3 | 60 |
| More than 3 cm to less than 6 cm | 12 | 48 | 11 | 92 |
| 6 cm and more | 8 | 32 | 8 | 100 |
| Total | 25 | | 22 | |

**Table 9** The relationship between the site of the tumor and the number of cases with brain edema.

| Site of the tumor | Cases | | Number of cases with brain edema | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Sphenoid ridge | 11 | 44 | 11 | 100 |
| Parasagittal | 6 | 24 | 6 | 100 |
| Convexity | 5 | 20 | 3 | 60 |
| Olfactory groove | 3 | 12 | 2 | 67 |
| Total | 25 | | 22 | |

Sphenoid ridge meningiomas were the most common of the recurrent meningiomas. Peritumoral brain edema was present in all cases under study in sphenoid ridge (Figs. 3 and 5) and parasagittal sites as shown in Table 9 followed by convexity meningioma (Figs. 1, 2 and 4).

The higher the histological grade of the meningioma, the more the preoperative brain edema index, the more difficult the tumor excision and the more the postoperative complications as shown in Table 10.

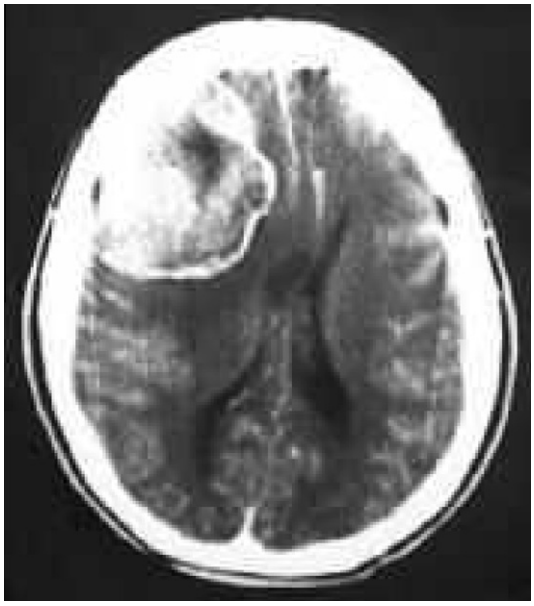

**Figure 1** Shows a preoperative axial computerized tomography scan of the brain showing a right frontal convexity meningioma with surrounding brain edema and midline shift.

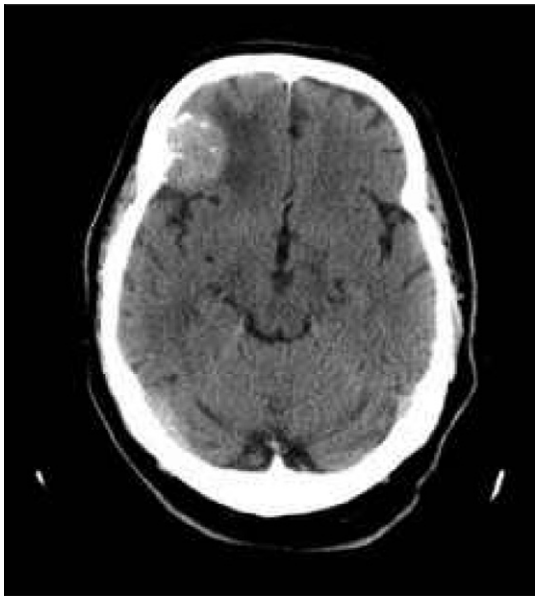

**Figure 2** Shows an axial CT scan of the brain, post contrast showing a right frontal convexity meningioma with surrounding brain edema.

## 5. Discussion

This was a retrospective study of 25 patients having recurrent meningioma that tried to correlate the presence of preoperative peritumoral brain edema before the first surgery to the incidence of tumor recurrence. All cases included in the study had Simpson grade6 one or two of tumor excision at the first operation.

Meningioma is mostly a benign tumor that can be cured by total surgical excision.11,13 However, recurrence occurs in almost 20% of cases.14,18 Many factors were linked to recurrence including gender, age, shape of the tumor surface, peritumoral brain edema and before all, the extent of tumor excision according to the Simpson grading system.17,19,20 Peritumoral brain edema is present in almost 60% of cases

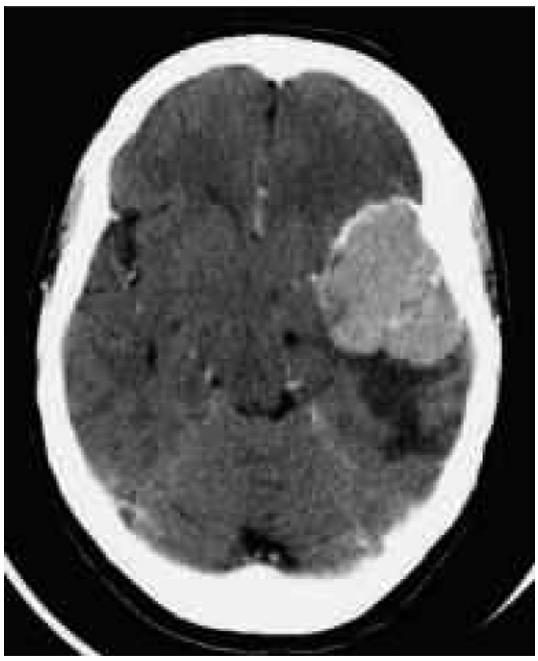

**Figure 3** Shows an axial CT scan of the brain, post contrast showing a left sphenoid ridge meningioma with surrounding brain edema.

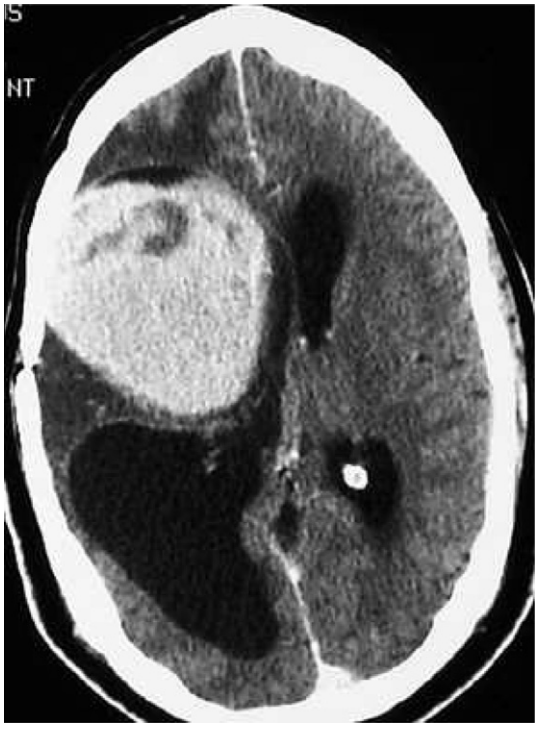


**Figure 4** Shows an axial CT scan of the brain, post contrast that shows a large recurrent right convexity meningioma with surrounding brain edema.

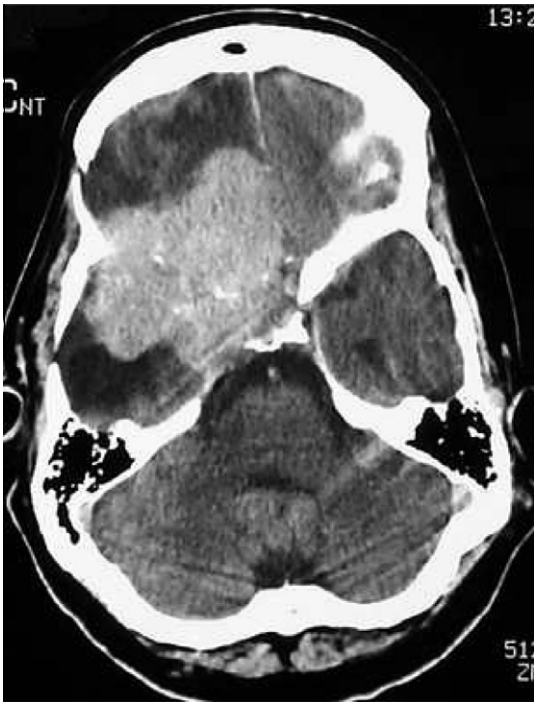

**Figure 5** Shows an axial CT scan of the brain, post contrast showing a recurrent right sphenoid ridge meningioma with surrounding brain edema.

of supratentorial meningioma. It is caused by the secretion of vascular endothelial growth factor by the tumor and is closely associated with the presence of cortical pial blood supply of the tumor.[21–23] Some reports imply the role of tumor cell invasion of the adjacent brain parenchyma, and this is associated with loss of the arachnoid plane between the tumor and the brain.[24–26]

In this study, most of the patients (72%) were in the age category of 40–60 years which correlated with most other studies.[27] Females were more than males in our study, which also correlates with other statistics.[28] Our study showed that the more the number of years since surgery, the higher the incidence of meningioma recurrence. Three to less than six years since surgery represented the highest category (52%) of cases; while the least recurrence was less than one year of surgery. We used the brain edema index in this study which was calculated by dividing the diameter of the brain edema in the preoperative computerized tomography scan at the cut that showed the largest tumor diameter by the tumor diameter at the same scan. We found that the more the brain edema index, the higher the incidence of recurrence (Table 4. Also the average years since surgery till recurrence decreased significantly with the increase in brain edema index (Table 5).

Brain edema had also an important impact on the incidence of occurrence of postoperative complications. Patients with preoperative brain edema index of two and more had an almost 73% complications rate as compared to 33% complications rate in patients who had brain edema index of less than one (Table 6). This was probably due to the loss of arachnoid plane due to tumor invasion of the brain parenchyma in patients with high preoperative brain edema index. The loss of arachnoid plane during tumor dissection from the brain tissue caused brain injury and hence postoperative complications. These results correlate with most other studies.[29]

Post operative complications were mainly weakness in 71% of cases, transient deterioration of consciousness in 50% of cases and seizures in almost 29% of cases (Table 7).

Our study showed that most of the cases had a maximum tumor size of 3 to less than 6 cm (48%) and that the larger the tumor size, the higher the incidence of preoperative peritumoral brain edema (Table 8). This was probably caused by the deeper invasion of tumor cells in the brain parenchyma in larger tumors which had a longer duration of growth, hence more time for tumor cells invading the brain. The deeper tumor cell invasion caused more secretion of vascular endothelial growth factor that caused more parenchymal brain edema. This correlated with other studies that indicated a higher incidence of peritumoral brain edema with larger tumor size.[30–32]

Sphenoid ridge meningioma (44%), followed by parasagittal meningioma (24%) represented the most common locations for recurrent meningioma in our study and both of them had preoperative peritumoral brain edema in all cases (Table 9). This corresponds with other studies that indicate that most cases of meningioma that had peritumoral brain edema were in the sphenoid ridge location.[33,34]

The higher the histological grade of the meningioma, the more the preoperative brain edema index, the more

**Table 10** The correlation between the histopathological subtype of meningioma, preoperative brain edema index, ease of tumor excision and postoperative complications.

| Histopathology of meningioma($n$ = 25) | Preoperative brain edema index | No. | Ease of tumor excision | No. | Postoperative complications | No. |
|---|---|---|---|---|---|---|
| Type I (benign) (21 patients) | Less than 1 | 6 | Easy | 11 | Weakness | 6 |
| | 1 to less than 2 | 8 | Difficult | 10 | Transient deterioration of consciousness | 4 |
| | 2 and more | 7 | | | Seizures | 2 |
| Type II (atypical) (3 patients) | Less than 1 | 0 | Difficult | 3 | Weakness 3 | |
| | 1 to less than 2 | 0 | | | Transient deterioration of consciousness | 2 |
| | 2 and more | 3 | | | Seizures | 2 |
| Type III (malignant) (1 patient) | Less than 1 | 0 | Difficult | 1 | Weakness | 1 |
| | 1 to less than 2 | 0 | | | Transient deterioration of consciousness | 1 |
| | 2 and more | 1 | | | Seizures | 0 |

difficult the tumor excision and the more the postoperative complications as shown in Table 10. As expected, the more malignant the histopathological subtype of the tumor, the more the tumor invasion of the brain parenchyma and therefore, loss of the arachnoid plane surrounding the meningioma results in more difficult tumor excision and therefore, more postoperative complications.12,1,29

At six months postoperatively, CT follow-up of the brain with contrast was done, and the brain edema was reported. Three cases in this study did not have preoperative peritumoral brain edema and remained so six months postoperatively. All the other cases that had preoperative peritumoral brain edema still had the edema 6 months postoperatively though to a lesser extent. This indicates the still persistent secretion of vasogenic brain edema factor by the remaining tumor cells in the brain parenchyma.

From this study, we concluded that preoperative brain edema as measured by brain edema index on the preoperative brain computerized tomography scan had an important impact on the postoperative complication rate as well as on the incidence of tumor recurrence. The more the preoperative peritumoral brain edema, the more the postoperative complication rate, the more the incidence of tumor recurrence and the less the duration needed for the tumor to recur. We recommend a careful surgical technique in removing meningiomas having high brain edema index and close follow-up postoperatively for these cases especially those in sphenoid ridge or parasagittal locations for early detection of tumor recurrence.

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