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Cohort Study

Are the clinical manifestations of CT scan and location associated with World Health Organization histopathological grades of meningioma?: A retrospective study

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ABSTRACT

Introduction: meningioma is the most common intracranial tumor. CT scan is a common method for diagnosis. WHO classified meningioma into 3 histological grades? This study aims to evaluate the relation of different meningioma signs on CT and tumor distribution regard to WHO histological types.
Methods: In this single-center observational retrospective study, authors reviewed data of 75 meningioma patients confirmed by the WHO histological grades (WHO I/II/III) which were underwent CT scans from January 1, 2005 to December 30, 2019 at a teaching hospital, in XXXX. Data collected using patients medical records. Data were analyzed by SPSS 20 and P less than 0.05 was assumed as significant.
Result: Our study confirmed that only edema ($P = 0.005$) and heterogeneity ($P = 0.014$) had a significant association with malignant histological types. Other signs were not statistically different among WHO histology types ($p > 0.05$). On the subject of tumor location, atypical/malignant meningioma was significantly more common in parasagittal ($P = 0.031$) and front-parietal ($P = 0.035$) regions.
Discussion: meningiomas with Edema, heterogeneity on CT, and tumors located in parasagittal and frontoparietal regions are related to malignant histology and should be evaluated and treated more precisely.

1. Introduction

Meningioma is the most common type of primary intracranial tumor (36.7%) [1]. Some of the most important risk factors for meningioma are age, sex, and race, as meningioma is more common in older age, female gender and African American race [2,3]. In recent years, the prevalence of meningioma has increased due to the increasing use of diagnostic imaging, increasing the accuracy of diagnostic methods, improving the reporting system and use of standard classification systems [4]. WHO classified meningioma into 3 grades, WHO grade I (benign), WHO grade II (atypical), WHO grade III (malignant) accounts for 80.3%, 17.9%, 1.6% of all meningioma's respectively [5]. Today, CT scan is one of the most frequent and accurate methods of diagnosing meningioma. On CT, meningioma is typically seen as a sharp, homogenous, hyperdense, extra-axial tumor that may accompany calcification, hemorrhage, edema, and bony changes [6]. Studies show more malignant features such as higher recurrence and mortality in higher WHO grades of meningioma [7]. The only definitive treatment for meningioma is surgery. The use of diagnostic methods in determining the exact stage and severity of the disease is crucial for choosing the type and severity treatment, especially in high grades of meningioma [8].

Because information about the relationship between tumor grade and clinical manifestations of meningioma CT scan can help surgeons make better decisions to choice the type of treatment and also, There are limited studies in this regard [8,9]. The aim of this study was to determine the association of clinical manifestations of CT scan, tumor location and WHO histopathological grades in meningioma patients.

2. Methods

In this single-center observational retrospective study, authors reviewed data of 75 meningioma patients confirmed by the WHO histological grades (WHO I/II) which were underwent CT scans from January 1, 2005 to December 30, 2019 at a teaching hospital, in ShTehran Tehran. This study was approved by the ethics committee of Shahid Beheshti Universoty of Medical Sciences. Due to the

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retrospective study, no consent was required. All pathology and radiology data were extracted using patient's medical records. The collected data were demographic characteristics of patients (age, gender) and clinical information (tumor grade based on WHO classification (I, II) [10], and CT scan features). Patients <18 years old or without sufficient information excluded. we included 75 files that mentioned WHO grade of tumor in their pathology reports plus having access to their CT scan report. Multiple lesions were not evaluated in the spinal cavity.

All data were entered to and analyzed by SPSS for WINDOWS® VER 20 (SPSS Inc., Chicago, IL, USA).

Different pathology grades regard to qualitative variables were analyzed by Pearson Chi-Square and Fisher's Exact Test and for analysis of continuous variables, an independent-samples *t*-test was used. A p-value of less than 0.05 was regarded as statistically significant. The study has been reported with accordance to the strengthening the reporting of cohort studies in surgery (STROCSS 2019) guidelines.

3. Results

3.1. Demographic characteristics

Data of 75 patients were included in this study. 68 (90.6%) were classified as WHO grade I and 7 (9.4%) were WHO grade II. Mean age (SD) for WHO grade I and grade II were 51.85(12.18) and 58.86(17.97) years respectively. Female/male ratios were 45/23 and 3/4 in the above-mentioned groups. Statistically, neither age nor sex had a significant difference between these 2 main groups ($p > 0.05$). (Table 1).

3.2. Main results

In the comparison of 2 main pathologic groups regard to different manifestations on brain CT scan, only edema ($p = 0.005$) and heterogeneity ($p = 0.014$) had a significant difference (Table 2). Although hypodense attenuation, calcification, cystic lesion, and mass effect were more common in WHO grade II and isodense attenuation, bone invasion, extracranial extension, multiple lesions, and normal CT were more common in WHO grade I, there was no statistically significant difference ($p > 0.05$) when comparing two main groups. Extracranial extension to visual apparatus including optic canal, optic nerve, and orbit was the most common pattern of invasion (5 (83.3%)). One of them had a nasal cavity extension rather than an orbital extension. One meningioma originated from CPA angel and was extended to the spinal cavity at the level of C2. Table 3 shows tumor distribution in different anatomical sites according to pathologic types. Parasagittal and frontoparietal regions were the most common sites of involvement in WHO grade II/III (33.3% and 44.4%, respectively).that is significantly different from WHO grade I ($p = 0.031$, $p = 0.035$ respectively). On contrary to WHO grade II/III meningioma, WHO grade I was mostly present (25%) in the sella-para sellar region (Table 3).

4. Discussion

Peritumoral edema is a common sign in brain CT of meningioma which prevalence is approximately 60% in several studies [11–13] . Several studies showed the association between edema (existence or size) and histopathologically malignant [14] or more recurrence [15] of meningioma; however, some studies found no significant association [8, 16]. We found peritumoral edema in CT of all patients with malignant pathology while it was only positive in 42.6% of benign tumors. Therefore similar to other studies we suggest edema as an important factor for the prediction of malignancy in meningioma to make a better plan for the management of the disease. Heterogenous enhancement may be caused by intratumoral hemorrhage, cysts, and necrosis [17]. Rockhill et al. showed heterogeneity is about 3 times more frequent in malignant meningioma [18]. As our study demonstrated this sign may be a predictor of malignant histology. Atypical density seen in 10–15% of cases may represent an unusual histological feature of the tumor [19]. Rockhill et al. noted a significantly higher percent of moderate adjacent hypodensity in malignant meningioma [18]. In our study hypodensity was about two times more common in malignant tumors but statistically, no significant association with histology was found. Bone invasion is seen in about 10% of meningiomas and maybe presented as a hyperostosis or osteolytic lesions in Brain CT scan of patients [20]. Although bone involvement in atypical meningioma was demonstrated to accompany with poor outcome [21], Hsua et al. study similar to ours showed it was not a predictor of the malignant histopathologic type of tumor. Like our study, Hsua et al. studies noted no significant relation of Hyperostosis on brain CT of patients regard to malignant histology [8]. Rockhill et al. found this sign more common in benign meningioma [18]. Osteolysis was shown to be a result of skull bone invasion or primary intraosseous meningioma [22]. It is shown to be associated with poor prognosis [23], more recurrence [24], and more aggressive features [25]

Table 1
Demographic characteristics of patients (N = 75).

Variable	Grade	
	Grade I	Grade II
Age M(SD)	51.85(12.18)	58.86(17.97)
Gender	45	3
Female	23	4
Male		

Table 2
A comparison of non-enhanced CT manifestations based on WHO pathologic grade.

Positive Tumor Manifestations	Grade I (N = 68) N (%)	Grade II (N = 7) N (%)	*P*-Value
Attenuation	37(74.0)	5(71.4)	0.885
Hyperdense	6(12.0)	2(28.6)	0.237
Hypodense	6(12.0)	0(0)	0.333
Isodense			
Bone invasion	9(15.5)	1(14.3)	0.932
Hyperostosis	7(12.1)	0(0)	0.331
Osteolysis			
Calcification	13(24.1)	3(42.9)	0.288
Cystic lesion	2(3.7)	1(14.3)	0.311
Dural tail	9(13.2)	1(14.3)	0.938
Edema	23(42.6)	7(100)	0.005
En-plaque	1(1.5)	0(0)	0.907
Extracranial extension	6(8.8)	0(0)	0.413
Heterogeneity	9(16.7)	4(57.1)	0.014
Mass Effect	32(59.3)	5(83.3)	0.391
Multiple lesions	4(5.9)	0(0)	0.544

Table 3
Tumor distribution in different anatomical sites according to WHO pathologic grade.

Site of Involvement	Grade I (N = 68) N (%)	Grade II (N = 7) N (%)	P value
Sella-parasella	17(25.0)	0(0)	0.001
Parasagittal	14(20.6)	4(57.1)	0.031
Sphenoid ridge	9(13.2)	1(14.3)	0.110
CPA angel	9(13.2)	0(0)	0.231
Fronto-parietal	4 (5.9)	2(28.6)	0.035
Tentorium	4(5.9)	0(0)	0.431
Olfactory groove	3(4.4)	0(0)	0.231
Cerebellar convexity	2(2.9)	0(0)	0.542
Temporo-parietal	2(2.9)	0(0)	0.423
Parieto-occipital	1(1.5)	0(0)	0.831
Intra ventricle	1(1.5)	0(0)	0.831
Anterior 3rd ventricle	1(1.5)	0(0)	0.831
Foramen Magnum	1(1.5)	0(0)	0.831
Spinal	1(1.5)	0(0)	0.831
Sylvian fissure	0(0)	0(0)	–

of the tumor. Despite these malignant features, Hsua et al., a study similar to ours demonstrated no significant association between this sign and histologically malignant tumor [8]. The relation of intratumoral calcification to malignant pathology or malignant behavior of the tumor is controversial. Rockhill et al. study demonstrated calcification as a predictor of benign meningioma [18]. Ildan et al. were noted no significant decrease in the recurrence of calcified meningioma [24]. In our study, this sign was 2 times more common in malignant histology but it's not significant, statistically. Cystic lesions may be intratumoral or reactive [(16)]. This sign may present in 1.7%–11.7% of patients with meningioma [8,26]. Hsua et al. study showed the cystic change as a predictor of atypical/malignant histology [8], In our study although this sign was about four times more common in meningiomas with malignant histology statistically no significant relation was found.

The dural tail is dural thickening extending away from the meningioma [19] In the majority of literature it was shown as a reactive and nonneoplastic lesion, however previously it was thought to be a sign of malignancy [27]· Ildan et al. demonstrated that the dural tail sign was not statistically associated with more recurrence [24]. Our study showed the distribution of this sign among different histological types did not significantly differ.

Orbit was the most common site of Extracranial Extension in our study. Thus any ophthalmological problem in patients with meningioma may be a manifestation of tumor extension. Contrary to Hsua et al.'s study, all of our cases with extracranial tumor extension had benign pathology [8]. Therefore this sign may not be of exact value in differentiating histologically benign and malignant tumors.

Midline shifts were shown to be more common in malignant tumors in Rockhill et al. study. In our study mass effects including midline shift are also more common in malignant meningiomas; however, statistically, no significant association was established [21].

Multiple meningiomas occur in less than 10% of cases 80–90% of multiple meningiomas are benign (WHO grade I) [19,28]. Our study compatible with others found all multiple lesions to have benign histology however significant difference in histology was not obtained.

In our study, hypodense attenuation, calcification, and cystic lesion were 2, 2, and 4 times more common in WHO grade II/III meningioma respectively; but while we compare these signs regard to histology, statistically no significant associations were found. Judgment about the relation of these signs to histology may become more precise when a study with more sample size takes place.

We showed sellar-parasellar (25%) and parasagittal(20.6%) regions as the most common site of involvement by benign meningioma. However malignant meningioma mostly affects parasagittal and frontoparietal regions. Sphenoid ridge was the third location affected by either benign or malignant tumors. Several literatures noted convexity and parasagittal regions [18,29] as the most common locations affected by atypical/malignant meningiomas. Rockhill et al.'s study also showed this pattern in benign meningiomas. Moreover like our study this study confirmed sphenoid ridge as the third site of involvement for all histological type [18].

The most important limitations of this study were: a. This was a retrospective and observational study that the specific limitations of this type of study should be considered when interpreting the results of the study. Two. Another limitation was the incompleteness of much of the patient information that was excluded from the study. Three. The sample size was small and was done in only one center. Strengths The most important strengths of this study were the long follow-up period that patients identified from 2005 to 2019.

5. Conclusion

The aim of this study was to determine the association of clinical manifestations of CT scan, tumor location and WHO histopathological grades in meningioma patients. Regarding CT scan indices for edema, heterogeneity, significant differences were observed in Grade I, and Grade II groups. Regarding the location of the tumor in Grade I, the tumors were significantly more in the parasagittal and frontoparietal part. In conclusion, because of the more common distribution of atypical/malignant meningioma in parasagittal and frontoparietal regions, we suggest more precise evaluation of tumors located in these regions.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2021.102365.

Ethical approval

This study was approved by the ethics committee of shahid beheshti Universoty of Medical Sciences.

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None.

Author contribution

All authors contributed evenly in drafting, collecting data, analysis, writing and proofreading of the paper.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Guarantor

Rezvaneh behzadmehr.

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