Mixed Atypical, Microcystic, And Angiomatous Meningioma: A Rare Radiologic And Histopathologic Findings

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Authors' contributions

NG, conceptualization, writing-original draft, writing-review & editing

LL, conceptualization, clinical data, interpretation, supervision, writing-review & editing

AP, clinical data, surgical data, supervision

RT, clinical data, interpretation, supervision

CONSENT

Consent was not obtained from the patient. No identifying information included in this case report.

HUMAN AND ANIMAL RIGHTS

All procedures conducted adhered to the ethical guidelines set by the institutional and national research committee, as well as the principles of the 1964 Helsinki Declaration and its subsequent amendments or equivalent ethical standards.

ETHICAL STATEMENT

The research adhered to the ethical principles of the Helsinki Declaration. All patient data were fully anonymized in the manuscript and related documents. Written consent was not obtained since there is no identifying information included in this case report.

CONFLICT OF INTEREST

None.

ABSTRACT

The occurrence of a mixed atypical, microcystic, and angiomatous meningioma is seldom encountered. To the best of the author's knowledge, no documented cases are reported to date that describe such a scenario. We report a 46-year-old female who presented to the emergency room after experiencing loss of consciousness preceded by a seizure and headache. Computed Tomography revealed a well-defined hypodense extra-axial mass in the left frontal region, described as an extra-axial cyst. Magnetic Resonance Imaging with intravenous contrast revealed a well-defined heterogeneous extra-axial lesion, isointense on T1-weighted images, hyperintense on T2-weighted images, and low intensity on Fluid Attenuated Inversion Recovery Images, consistent with the characteristics of a cyst. An irregular restricted diffusion area was observed in the center of the lesion on diffusion-weighted images. Striated vascular architecture was visible on the post-contrast T1 image. Histopathological findings of the tumor tissue confirm the diagnosis of mixed atypical, microcystic, and angiomatous meningioma. This case report discusses the radiological findings that provide diagnostic clues for meningiomas, specifically the atypical, microcystic, and angiomatous subtypes, along with their corresponding differential diagnoses.

CASE REPORT

BACKGROUND

Meningiomas are the most common primary brain tumors, accounting for over one-third of intracranial neoplasms. Their incidence increases with age, being more prevalent in individuals over 40 years old. They also show a female predominance, with an incidence rate ratio of 2.33 compared to males [1].

The World Health Organization (WHO) classifies meningiomas into three grades: I, II, and III. Grade I meningiomas are the most common and include subtypes such as meningothelial, fibrous, transitional, angiomatous, and microcystic meningiomas [1,2]. Among these, microcystic and angiomatous meningiomas are rare, accounting for

approximately 1.6% and 2.1% of all cases, respectively [3,4]. Grade II includes atypical meningiomas, which represent over 90% of cases in this category and have a higher recurrence risk. Grade III meningiomas, including anaplastic variants, are aggressive and associated with poor outcomes [1].

Histopathological analysis of this case revealed a rare mixed pattern of atypical (Grade II), microcystic (Grade I), and angiomatous (Grade I) meningiomas. While some reports describe mixed meningiomas, most involve only two subtypes [5,6,7]. However, to the best of the authors' knowledge, there are no existing articles reporting on a case involving a mixture of three meningioma subtypes as observed in this patient, specifically atypical, microcystic, and angiomatous meningiomas. This case highlights a rare radiologic and histopathologic presentation, adding to the understanding of meningioma subtypes.

CASE REPORT

A 46-year-old female presented to the emergency room after experiencing a second episode of loss of consciousness since morning prior to admission. The patient's guardian reported that the patient had experienced a seizure lasting approximately three minutes before losing consciousness. The patient also complained of having a persistent mild tension headache since the morning preceding admission. There were no complaints of nausea, vomiting, or weakness on one side of the body. The patient has no history of seizures, other systemic diseases, surgical procedures, or medication use. The patient's family also denies any history of malignancy or similar complaints among family members. The patient exhibited intact consciousness and orientation. Vital signs were within normal limits. A 0,5 cm bite mark laceration was found on the patient's tongue. There were no neurological deficits observed on neurological examination. Complete blood count, electrolyte, and blood glucose were within normal limits.

The patient was consulted to a neurologist and was referred for a brain Computed Tomography (CT). CT revealed a well-defined hypodense extra-axial mass in the left frontal region measuring 5.1 x 4.7 x 2.8 cm, described as an extra-axial cyst (Figure 1a-1c). The mass exhibited a mass effect, resulting in perifocal edema in the left frontal lobe, with a slight compression of the anterior horn of the left lateral ventricle and a 7 mm midline shifting to the right (Figure 1d). Magnetic Resonance Imaging (MRI) with contrast was performed for further investigation. MRI with intravenous contrast revealed a well-defined heterogeneous extra-axial lesion, hypointense on T1-weighted images (T1-WI), hyperintense on T2-weighted images (T2-WI), with low intensity on T2-weighted images-Fluid Attenuated Inversion Recovery (T2-FLAIR) (Figure 2). The T2-FLAIR images show perilesional edema with mild compression of the left lateral ventricle and midline shifting of 7 mm was observed. There was an irregular restricted diffusion area in the center of the lesion. Striated vascular architecture was visible on the post-contrast T1 image (Figure 3).

The patient was referred to neurosurgery department. Craniotomy with tumor resection was performed one month following the patient's first admission, based on the patient's and patient's family preferences. The histopathological examination of tumor tissue obtained through surgery revealed a mixed histologic subtype of atypical, microcystic, and angiomatous meningioma. The patient was discharged after 3 days and no complaints were found on the one-week postoperative follow-up visit.

DISCUSSION

Epidemiology & Classification

Meningiomas are the most common intracranial tumor, making up more than one-third of all brain neoplasms. These tumors originate from the meninges. Meningiomas are mostly benign slow-growing tumors that can be observed or treated with surgical resection that provides good outcomes. The incidence of meningiomas increases with age. The incidence rate in patients more than 40 years old is 18.69/100.000 and 0.16/100.000 in age 0-19 years. Meningiomas are more common in females, with incidence rate ratios of 2.33 and 1.12, respectively [1].

According to the World Health Organization (WHO) histologic classification of central nervous system tumors, subtypes of meningiomas are classified into grade I, grade II, and grade III. WHO grade II and III and meningiomas of any subtype with a high proliferation index have a greater likelihood of recurrence and aggressive behavior. Most meningiomas belong to grade I which includes meningothelial, fibrous, transitional, psammomatous, angiomatous, microcytic, secretory, metaplastic meningioma, and lymphoplasmacytic-rich meningioma [1]. The most common subtypes are WHO grade I meningothelial, fibrous, and transitional meningiomas [2]. Microcystic and angiomatous meningiomas are two rare subtypes of meningioma, constituting approximately 1.6% and 2.1% of all meningioma cases, respectively [3,4].Grade II consists of atypical, clear cell, and choroid meningioma. More than 90% of grade II meningioma cases are of the atypical subtype. Grade III consists of anaplastic, rhabdoid, and papillary meningioma [1]. Based on the histopathological examination of the patient's tumor tissue, a mixed histologic subtype of atypical meningioma, classified as a grade II meningioma, was identified, accompanied by features of microcystic and angiomatous meningioma, which are two rare subtypes of grade I meningioma.

Based on the author's research, there have been no studies detailing the epidemiology of mixed type meningioma although rare cases of mixed type meningiomas, such as mixed microcystic and angiomatous meningioma, atypical meningioma with microcystic changes, and fibrous meningioma with areas of microcystic meningioma, have been previously described in several case reports [5-7]. However, to the best of the authors' knowledge, there are no existing articles reporting on a case involving a mixture of three meningioma subtypes as observed in this patient, specifically atypical, microcystic, and angiomatous meningiomas.

Etiology & Risk Factor

Most meningiomas arise spontaneously, but certain conditions and risk factors have been linked to their development. Environmental elements, including obesity, alcoholism, exposure to ionizing radiation, radiotherapy, and hormonal influences such as exposure to exogenous hormones, hormonal replacement therapy, use of oral contraceptive pills, and breast cancer, can elevate the likelihood of meningioma occurrence [8].

Meningiomas demonstrate the presence of progesterone, estrogen, and androgen receptors on their cell membranes. Progesterone receptors are detectable in up to 72% of these tumors. Research indicates fluctuations in tumor size during pregnancy and the luteal phase of the menstrual cycle. The higher prevalence in females can be attributed to hormonal factors. Additionally, there is a notable association between meningioma incidence and affected first-degree relatives. Several genetic mutations have been linked to the development of meningiomas. A mutation on chromosome 22 associated with neurofibromatosis type 2 is one of the most frequent predisposing factors observed in sporadic meningiomas. Additionally, mutations on chromosomes 1p, 6q, 14q, and 18q have been reported in meningiomas. Inherited meningiomas have also been associated with mutations in genes such as CREB-binding protein, protein patched homolog 1, phosphatase and tensin homolog, cyclin-dependent kinase inhibitor 2A, Von Hippel–Lindau, and neurofibromatosis 1[8].

Clinical Findings

The clinical manifestation of meningioma depends on its location and size. Meningiomas are usually asymptomatic. Clinical symptoms including headache due to increased intracranial pressure, focal neurological deficits, or generalized and partial seizures caused by focal mass effect, are typical. Personality changes, confusion, and altered level of consciousness can be seen, especially in anterior (frontal) or parasagittal meningiomas, and they may be initially misdiagnosed as dementia or depression. The differential diagnosis of a patient presenting with such symptoms is broad and should include other intracranial lesions[1]. A tonic-clonic seizure preceded by headache is the presenting symptom of this patient.

Radiographic Findings

The general appearance of a benign or typical (WHO grade I) meningioma is a well-defined, rounded, or lobulated, extra-axial dural-based mass that pushes the cortex inward. The cerebrospinal fluid (CSF) cleft sign is a distinguishing indicator that differentiates extra-axial and intra-axial masses. This sign is typically employed in the description of a meningioma. Meningiomas rarely invade the brain parenchyma. When present, it indicates atypical meningioma (WHO grade II). Meningiomas are most commonly located in the parasagittal area (25%), brain convexity (20%), and sphenoid ridge (15-20%). Other less common locations of meningiomas include the posterior fossa (8-10%), olfactory groove (5-10%), para sellar (5-10%), intraventricular, pineal, extracranial, and intraosseous (< 2%). In this case, the tumor was found in the brain convexity, more precisely in the left frontal region with no brain parenchyma invasion [9].

In addition to those mentioned above, there is a very rare type of extracranial meningioma known as sinonasal meningioma. This type of tumor has not been extensively studied, but in such cases, the tumor can be evaluated using PET scan with [68Ga] Ga-labeled somatostatin receptor ligands to provide information on the expression of somatostatin receptors in the tumor [10].

CT Findings

Almost 75% of meningiomas are mild to moderately hyperdense compared with cortex, and the rest are isodense. Hypodense meningiomas are uncommon. However, in this patient, a hypodense lesion was observed on CT imaging [9]. Some studies have suggested that cystic changes, necrosis, fatty infiltration, and previous hemorrhage could potentially account for hypodense areas on CT scans in certain meningiomas [11]. Peritumoral vasogenic edema is present in more than 50% of all cases. Bone window CT may show hyperostosis of the skull. Bone destruction can also occur in both benign and malignant meningiomas and is not predictive of tumor grade. The majority of meningiomas enhance strongly and homogeneously on contrast-enhanced computed tomography (CECT). Complete hypodensity in a meningioma may also be attributed to the microcystic structure of the lesion, as observed in this patient [9].

MRI Findings

MRI is the imaging modality of choice for the diagnosis of meningioma [8].Typically, meningiomas appear isointense to slightly hypointense on T1-WI and isointense to moderately hyperintense on T2-WI. In this case, MRI findings reveal a hypointense lesion on T1-WI, hyperintense on T2-WI, and low intensity on FLAIR, consistent with the characteristics of a cyst [12]. This is likely attributed to the microcystic structure of the lesion[7]. All meningiomas demonstrate at least some enhancement following contrast administration. Over 95% of meningiomas enhance homogeneously [9]. Heterogeneous enhancement might appear secondary to the presence of intrinsic cysts, calcification, and necrosis [12]. In this patient, striated vascular enhancement is observed. This striated vascular architecture indicates the presence of vascular channels within the lesion, which is one of the characteristics of angiomatous meningioma [3].

FLAIR is useful to depict peritumoral edema, which is found in approximately half of all meningiomas. Peritumoral edema is related to the presence of blood supply from the pia mater and vascular epithelial growth factor expression, not the tumor grade. Dural "tail" is seen in about 60% of meningiomas. However, a "dural tail" sign is not pathognomonic of meningioma. Perfusion MR may help distinguish typical meningiomas from atypical/ malignant meningiomas. High relative cerebral blood volume (rCBV) in the lesion or the peritumoral edema suggests a more

aggressive tumor grade. Most meningiomas do not exhibit restricted diffusion on diffusion-weighted images (DWI). However, an irregular area with restricted diffusion was found in this case. This may indicate the presence of a higher-grade component of the tumor within this lesion [9].

Treatment and Prognosis

The "wait-and-see" observation strategy is a commonly employed approach for patients incidentally diagnosed with small (tumor diameter ≤3 cm) asymptomatic meningiomas. The patient undergoes regular MRIs until the tumor reaches a size warranting intervention or if any symptoms appear. As recommended by the European Association of Neuro-oncology (EANO), a contrast-enhanced MRI is advised to be done six months post-initial diagnosis to assess any changes in the tumor. If the patient remains asymptomatic, subsequent follow-ups are scheduled annually for the first five years and every 2 years thereafter [1].

Surgical resection is the primary intervention for symptomatic meningiomas that do not respond to observation or for large tumors expected to cause symptoms imminently. Gross total resection, as performed in this patient, has the potential to cure a significant majority of patients, ranging between 70% and 80% [1]. Radiation therapy has emerged as a primary therapeutic approach for unresectable meningiomas, particularly those situated in challenging anatomical locations such as certain skull base meningiomas that have enveloped neurovascular structures. In the context of WHO grade I meningiomas following subtotal resection or in cases of recurrent surgically treated meningiomas, stereotactic radiosurgery or fractionated radiotherapy may be considered as viable options. Patients experiencing recurrent or progressive meningiomas unresponsive to surgical or radiotherapeutic interventions are treated with salvage systemic therapy. The European Association of Neuro-Oncology (EANO) categorizes the utilization of systemic therapy as experimental, supported by only level C evidence, hence abstaining from providing specific recommendations. The National Comprehensive Cancer Network (NCCN) advocates for the use of α-IFN, somatostatin receptor agonists, and vascular endothelial growth factor (VEGF) inhibitors in meningioma treatment. However, the efficacy of these interventions is markedly limited [1].

In addition to the previously mentioned therapeutic options, there is a case report indicating that the use of ^{177}Lu-dotatate has successfully halted the rapid growth of WHO grade III meningioma that were refractory to numerous prior therapies. ^{177}Lu-dotatate is a theranostic radioisotope for targeted radionuclide therapy, which was FDA-approved in 2018 for the treatment of somatostatin receptor-positive gastroenteropancreatic neuroendocrine tumors. Although further studies are necessary to evaluate the efficacy of this therapy, ^{177}Lu-dotatate could be considered as a potential treatment option for somatostatin receptor-positive meningiomas that do not respond to other therapies [13].

The most reliable prognostic indicators for meningiomas are the WHO histological grading of meningioma and the Simpson grading for tumor resection. Despite aggressive therapeutic interventions, the 10-year overall survival rates for WHO grade I, II, and III meningiomas are 83.7%, 53%, and 0% respectively. The 5-year recurrence rates of WHO grade I, II, and III meningiomas after Simpson grade I gross total resection are 7-23%, 50-55%, and 72-78%, respectively [1].

Differential Diagnosis

Arachnoid Cyst

An arachnoid cyst also known as meningeal cyst is a CSF (cerebrospinal fluid)-containing cyst lined by arachnoid cells. Most arachnoid cysts are supratentorial. Nearly two-thirds of cases are found in the middle cranial fossa, and about fifteen percent are found in the cerebral convexities, predominantly in the frontal lobes. Nearly 75% of cases are found in children and young adults with no sex difference. Most arachnoid cysts are asymptomatic. Symptoms vary with the location and size with headache as the most common presenting symptom reported. Uncomplicated arachnoid cysts have the same density as CSF on CT. Arachnoid cysts are well-defined, somewhat scalloped-appearing lesions that have parallel CSF signal intensity on T1-WI and T2-WI. Arachnoid cysts suppress completely on FLAIR. They do not show restricted diffusion on DWI and do not enhance with contrast administration [9].

Epidermoid Cyst

Epidermoid cysts are benign extra-axial lesions that arise from retained ectodermal epithelium during neural tube closure. Epidermoid cysts represent about 0.2–1.8% of all primary intracranial tumors. There is no gender predilection for epidermoid cysts and it typically occurs between the ages of 20–60 years, with a peak incidence in the fourth decade. Headache and seizures were the most common presenting symptoms. Epidermoid cysts are frequently found in the posterior fossa, particularly within the cerebellopontine angle cistern, which represents the most prevalent location. Radiographically, these cysts typically manifest as areas of hypodensity CT, hypointensity on T1-WI, and hyperintensity on T2-WI, closely resembling CSF. Epidermoid cysts exhibit restricted diffusion on DWI. Enhancement is generally absent although mild peripheral enhancement can be seen in 25% of cases. In certain instances, epidermoid cysts may present with atypical radiological features, such as heightened density on CT scans and spontaneous increased signal intensity on T1-WI [9,14].

Dermoid cyst

Dermoid cysts are much less common than epidermoid cysts. Presentation occurs at younger ages compared to epidermoid cysts, with peak incidence in the second and third decades. Dermoid cysts arise from ectodermal cells at the time of the neural tube closure. Dermoid cysts are most commonly located over the suprasellar cistern, followed by the posterior fossa and frontonasal region. Dermoid cysts often remain asymptomatic until they rupture. Although not fatal, meningitis with seizure, coma, vasospasm, and infarction may occur as a consequence. Dermoid cysts are mildly hypodense on CT. Most dermoid cysts

are heterogeneously hyperintense on T1-WI. Fat suppression is helpful to confirm the presence of lipid elements within the cyst. Fat is very hypointense on standard T2-WI. Uncomplicated dermoid cysts are heterogeneously hyperintense on FLAIR. Ruptured dermoid cysts demonstrate sulcal hyperintensity. Most dermoid cysts do not enhance with contrast administration [9,14].

Dural Metastasis

Dural metastasis can be virtually indistinguishable from meningiomas. Dural metastasis originates from cancers of the breast (34%), prostate (17%), and lung (13%), although others including bowel and germ cell tumors have also been described. On imaging, these lesions manifest as localized nodular thickening of the dura. There may be an association with vasogenic edema and when these lesions attain significant size, they exert indentation on the cortex. They enhance strongly, and like meningiomas, the dural tail is observed in nearly fifty percent of cases. On occasion, these lesions are linked to spontaneous subdural or, in rare instances, parenchymal hemorrhage. On CT, dural metastasis lesions exhibit higher density compared to the cortex. Soft tissue metastases typically infiltrate and lead to the destruction of the neighboring skull. On T1-WI, lesions typically appear isointense or hypointense, while on T2-WI, the signal intensity is variable, occasionally being predominantly hyper- or hypointense. Approximately one-third of patients display direct invasion into brain parenchyma. Lesions tend to exhibit facilitated diffusion on DWI. In comparison to meningiomas, most dural metastases manifest reduced perfusion, characterized by typical rCBV values of less than 2 [9].

Solitary fibrous tumors/hemangiopericytomas

Solitary fibrous tumors are rare mesenchymal tumors that usually occur in the mediastinum, abdomen, and skin. Infrequently, they arise intracranially, predominantly from the meninges. Intracranial solitary fibrous tumors almost always occur extra-axially, commonly exhibiting lobulated structures with dural attachment. On CT, they appear as heterogeneous isodense to hyperdense lesions. Smooth erosion of the overlying skull is seen in around 57% of cases. There is no overt destruction of the overlying skull in low-grade lesions. On MRI, the lesions exhibit a homogeneous and isointense signal on T1-WI and almost always appear as a heterogeneous pattern with a low signal on T2-WI. A small subset also presents a dural tail sign. Areas containing collagen material appear as curvilinear streaks or large regions with hypointense signals on both T1-WI and T2-WI. These features contribute to a visual pattern described as the 'Yin-Yang' pattern. Solid regions of the tumor demonstrate restricted diffusion on DWI. On perfusion imaging, solitary fibrous tumors are hyperperfused with rCBV values of 7 to 7.5. While these values are similar to meningiomas, this can help differentiate solitary fibrous tumors from other extra-axial lesions such as metastases [9].

CONCLUSION

Mixed type meningioma is a rare finding. This tumor type exhibits varied radiographic features and may resemble several other types of extracranial masses. Therefore, it is important for radiologists and clinicians to recognize the radiographic characteristics of mixed type meningioma to prevent misdiagnosis, ensuring appropriate management for the patient.

TEACHING POINTS

Meningioma is a predominantly benign tumor with varied clinical presentations ranging from asymptomatic cases to manifestations such as headache, focal neurological deficits, generalized and partial seizures, personality changes, confusion, and altered levels of consciousness. On CT, most meningiomas are mild to moderately hyperdense compared with cortex, and the rest are isodense. Peritumoral vasogenic edema is present in more than 50% of all cases. The majority of meningiomas enhance strongly and homogeneously on CECT. Hypodense meningiomas are uncommon. However, some studies have suggested that cystic changes, necrosis, fatty infiltration, and previous hemorrhage could potentially account for hypodense areas on CT in certain meningiomas. Complete hypodensity can be observed in cases of microcystic meningioma.

MRI is the imaging modality of choice for the diagnosis of meningiomas. Typical meningiomas appear isointense to slightly hypointense on T1-WI and isointense to moderately hyperintense on T1-WI. Dural tail can be found in 60% of cases. The presence of diffusion restriction on DWI indicates a higher grade of meningiomas. Microcystic meningioma may appear hypointense on T1-WI, hyperintense on T2-WI, with low intensity on FLAIR, consistent with the characteristics of a cyst. Striated vascular enhancement depicting the presence of vascular channels can be observed in cases of angiomatous meningioma.

Based on the findings in this case, radiographically, mixed atypical, microcystic, and angiomatous meningioma can exhibit varied appearances, demonstrating characteristics of all three types of meningioma. CT scan revealed a well-defined hypodense mass located outside the brain resembling an extra-axial cyst. MRI with intravenous contrast showed a distinct heterogeneous lesion located outside the brain, appearing hypointense on T1-WI, hyperintense on T2-WI, with low intensity on T2-FLAIR images. Perilesional edema was also observed on T2-FLAIR. Additionally, a restricted diffusion area was identified in the central part of the lesion, and a striated vascular architecture was visible on the post-contrast T1-weighted image.

QUESTIONS

Question 1: Which of these is not true about meningiomas

1. Meningiomas are the most common intracranial tumor, making up more than one-third of all brain neoplasms.
2. Meningiomas are more commonly found in females.
3. According to the WHO histologic classification of central nervous system tumors, grade I meningiomas have a greater likelihood of recurrence and aggressive behavior. (applies)
4. The clinical manifestation of meningioma depends on its location and size.
5. Meningiomas can be asymptomatic.

Correct answer: 3

Explanation: According to the WHO histologic classification of central nervous system tumors, subtypes of meningiomas are classified into grade I, grade II, and grade III. WHO grade I meningiomas are also called typical meningiomas, which are the benign subtypes of meningioma. Grade II and III meningiomas of any subtype with a high proliferation index have a greater likelihood of recurrence and aggressive behavior.

Question 2: Which of the following statements is false

1. Meningioma is an extra-axial dural-based mass
2. Meningiomas rarely invade the brain parenchyma
3. Meningiomas are most commonly located in the parasagittal area
4. Most meningiomas are hypodense on computed tomography (applies)
5. Peritumoral vasogenic edema is found in more than 50% of meningioma cases

Correct answer: 4

Explanation: Hypodense meningiomas are uncommon. Almost 75% of meningiomas are mild to moderately hyperdense on computed tomography.

Question 3: Which of these is not true about the radiographic features of meningiomas

1. Typically, meningiomas appear isointense to slightly hypointense compared with cortex on T1-weighted images
2. Most typical meningiomas are isointense to moderately hyperintense compared with cortex on T2-weighted images
3. All meningiomas demonstrate at least some enhancement following contrast administration
4. Microcystic meningiomas can appear as a hypodense lesion on computed tomography
5. Peritumoral edema is related to tumor grade (applies)

Correct answer: 5

Explanation: Peritumoral edema is related to the presence of blood supply from the pia mater and vascular epithelial growth factor expression, not the tumor grade.

Question 4: Which of these statements is false

1. Dural tail is seen in about 60% of meningiomas
2. The presence of vascular channels within the lesion is one of the characteristics of angiomatous meningioma
3. A High relative cerebral blood volume in the lesion or the peritumoral edema suggests a more aggressive tumor grade
4. Most meningiomas restrict on diffusion-weighted images (applies)
5. Diffusion restriction on diffusion-weighted images may indicate a higher grade of meningioma

Correct answer: 4

Explanation: Most meningiomas do not exhibit restricted diffusion on diffusion-weighted images. Diffusion restriction on diffusion-weighted images may indicate a higher grade of meningioma although it is not universally used to predict the histological grade of meningioma.

Question 5: Which of these is not true about the treatment and prognosis of meningiomas

1. The "wait-and-see" observation strategy is a commonly utilized approach for patients with small tumors, regardless of the presence or absence of symptoms (applies)
2. Surgical resection is the primary intervention for symptomatic meningiomas that do not respond to observation or for large tumors expected to cause symptoms imminently
3. Gross total resection has the potential to cure a significant majority of patients, ranging between 70% and 80%
4. Radiation therapy has emerged as a primary therapeutic approach for unresectable meningiomas
5. The most reliable prognostic indicators for meningiomas are the WHO histological grading of meningioma and the Simpson grading for tumor resection

Correct answer: 1

Explanation: The "wait-and-see" observation strategy is a commonly employed approach for patients incidentally diagnosed with small (tumor diameter ≤3) asymptomatic meningiomas.

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FIGURES

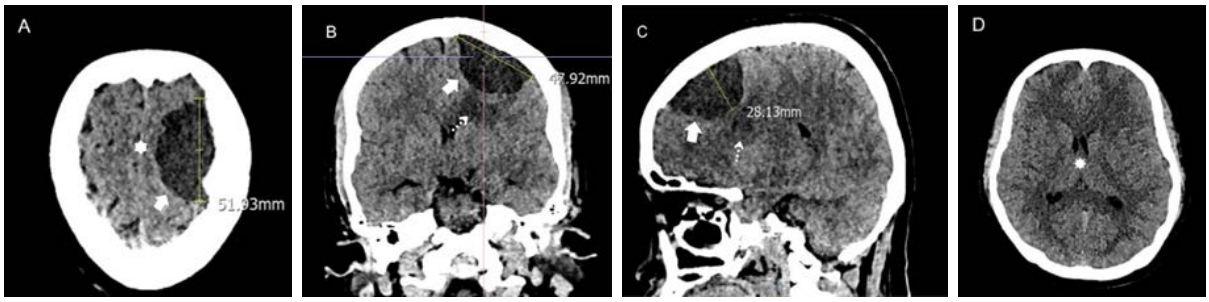

Figure 1: A 46-year-old female with mixed atypical, microcystic, and angiomatous meningioma.
FINDINGS: Axial (a,d), coronal (b), and sagittal (c) CT images reveal a well-defined hypodense extra-axial mass in the left frontal region measuring 5.1 x 4.7 x 2.8 cm (arrows). The mass exhibited a mass effect resulting as a perifocal edema (dotted arrows), with a 7 mm midline shifting to the right (asterisk).
TECHNIQUE: CT Brain, 207 mAs, 120 kV, 0.75 mm slice thickness.

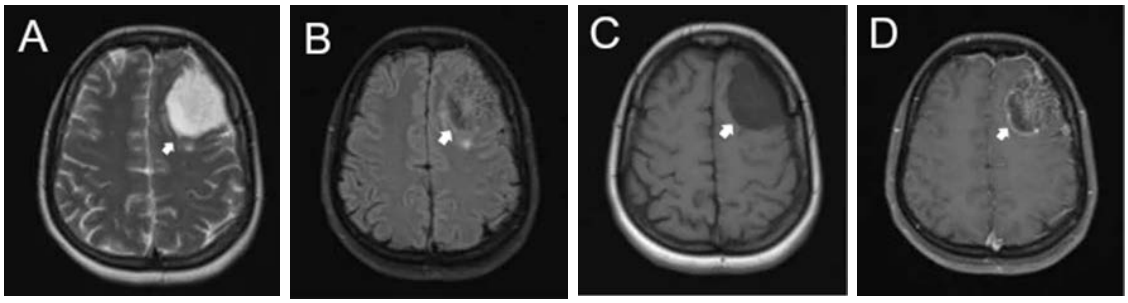

Figure 2: A 46-year-old female with mixed atypical, microcystic, and angiomatous meningioma.
FINDINGS: Axial MR images reveal a well-defined heterogeneous extra-axial lesion (arrows) appearing hyperintense on T2-WI (A) with low intensity with internal heterogeneous intermediate signal on T2-FLAIR (B), hypointense on T1-WI (C) with visible intralesional striated vascular architecture on contrast-enhanced T1-WI (D).
TECHNIQUE: 1.5T MRI scanner Sempra Siemens, supine position using head coil. T2W axial [TR 4370ms, TE: 95ms], T2W axial dark fluid [TR 8000ms, TE: 86ms], non-contrast T1W axial spin echo [TR 550 ms, TE: 9 ms]. Contrast-enhanced axial T1W spin echo image acquired after intravenous 0.2 mL/kg body weight of Gadoterate Meglumine administration [TR: 552ms, TE 17 ms].

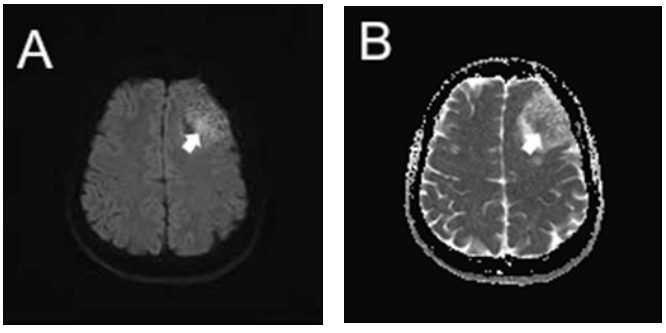

Figure 3: A 46-year-old female with mixed atypical, microcystic, and angiomatous meningioma.
FINDINGS: Axial DWI (A) and corresponding ADC (apparent diffusion coefficient) map (B) reveal an irregular restricted diffusion area in the center of the lesion (arrows).
TECHNIQUE: 1.5T MRI scanner Sempra Siemens, supine position using head coil. DWI and corresponding ADC map, b-values 1000s/mm^2 [TR: 4200 ms, TE: 76 ms].

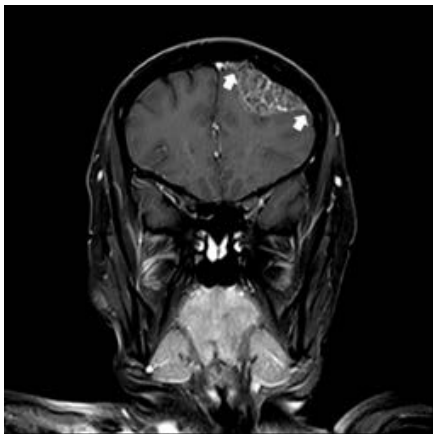

Figure 4: A 46-year-old female with mixed atypical, microcystic, and angiomatous meningioma.
FINDINGS: Coronal contrast-enhanced T1-WI reveal the appearance of dural tail (arrows).
TECHNIQUE: 1.5T MRI scanner Sempra Siemens, supine position using head coil. Contrast-enhanced coronal T1-spin echo [TR: 552 ms, TE: 17 ms].

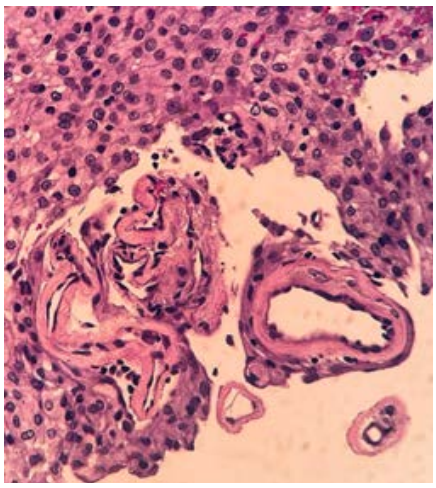

Figure 5: Histopathological examination of the obtained specimen stained with hematoxylin and eosin with a magnification of 40x reveals blood vessels with hyalinized walls (angiomatous meningioma), amidst a background of densely cellular meningothelial cells arranged in sheets (atypical meningioma).

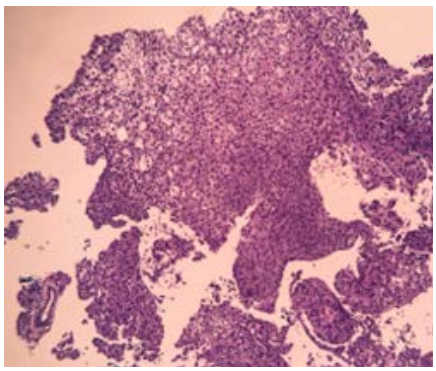

Figure 6: Histopathological examination of the obtained specimen stained with hematoxylin and eosin with a magnification of 10x depicts a microcystic tumor mass amidst a background of atypical meningioma on the upper left quadrant.

TABLES

Table 1: Summary table of mixed atypical, microcystic, and angiomatous meningioma

Etiology	**Unclear; most meningiomas arise spontaneously**
Incidence	Microcystic and angiomatous meningiomas are two rare subtypes of meningioma, constituting approximately 1.6% and 2.1% of all meningioma cases, respectively. More than 90% of grade II meningioma cases are of the atypical subtype. However, to the best of the author's knowledge, there are no documented cases of mixed atypical, microcystic, and angiomatous meningioma.
Gender ratio	More common in females than male with incidence ratios of 2.33 and 1.12, respectively.
Age predilection	Increases with age.
Risk factors	Obesity, alcoholism, ionizing radiation exposure, and female hormonal influences.
Treatment	“Wait-and-see” observation for small asymptomatic tumors, surgical resection for larger and symptomatic tumors, and radiation therapy for unresectable tumors.
Prognosis	Variable between grades of tumor.
Findings on Imaging	CT: a well-defined hypodense lesion resembling extra-axial cysts. MRI: a well-defined extra-axial lesion appearing hypointense lesion on T1-WI with post-contrast striated vascular enhancement, hyperintense on T2-WI, low intensity on FLAIR with marked peritumoral edema, and restricted diffusion on DWI. Dural tail is seen in about 60% of cases.

Table 2: Differential diagnosis table of mixed atypical, microcystic, and angiomatous meningioma

Differential Diagnosis	**CT**	**MRI**
Arachnoid cysts	Supratentorial extra-axial lesions, exhibiting hypodensity and mirroring the density characteristics of CSF.	Lesions characterized by well-defined and scalloped borders, demonstrating CSF signal intensity on T1-WI and T2-WI. These lesions exhibit complete suppression on FLAIR, no evidence of restricted diffusion on DWI, and do not enhance with contrast administration.
Epidermoid cysts	Extra-axial lesions in the posterior fossa, presenting as hypodense formations closely resembling CSF.	Extra-axial lesions exhibiting a hypointense appearance on T1-WI and a hyperintense on T2-WI. These lesions typically show restricted diffusion on DWI and generally do not display enhancement.
Dermoid cysts	Slightly hypodense extra-axial lesions, often situated over the suprasellar cistern, posterior fossa, or frontonasal region.	Dermoid cysts typically exhibit heterogeneously hyperintense signals on T1-WI, hypointense signals on T2-WI, and heterogeneously hyperintense signals on FLAIR. These cysts generally do not enhance with contrast administration.
Dural metastasis	Hyperdense localized nodular thickening of the dura that commonly destroys the neighboring skull.	Isointense to hyperintense on T1-WI, variable intensity on T2-WI, facilitated diffusion on DWI, with one-third of cases displaying direct invasion to the brain parenchyma.
Solitary fibrous tumors / Hemangiopericytomas	Heterogeneous isodense to hyperdense extra-axial lesions with smooth erosion of the overlying skull.	Homogeneous isointense lesions on T1-WI, hypointense on T2-WI, featuring collagen-containing areas manifesting as curvilinear streaks in a distinctive "Yin-Yang" pattern. The tumor demonstrates restricted diffusion on DWI.

KEYWORDS

Meningioma; Atypical; Microcystic; Angiomatous; Magnetic Resonance Imaging; Computed Tomography

ABBREVIATIONS

CT = Computed Tomography
EEG = Electroencephalogram
MRI = Magnetic Resonance Imaging
T1-WI = T1-Weighted Images
T2-WI = T2-Weighted Images
FLAIR = Fluid Attenuated Inversion Recovery
DWI = Diffusion-Weighted Images
ADC = Apparent Diffusion Coefficient
CECT = Contrast-Enhanced Computed Tomography
rCBV = Relative Cerebral Blood Volume
VEGF = Vascular Endothelial Growth Factor
CSF = Cerebrospinal Fluid

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