Clinicopathological insights of supratentorial embryonal tumor with medulloblastoma-like histopathology in adulthood: A case report

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Abstract. Embryonal tumor with medulloblastoma-like histopathology (ETMH) is an embryonic-type malignancy originating from remnants of primitive embryonic cells. It is rarer in adults, especially those over the age of 40. Adult ETMH occurring in the supratentorial region is extremely rare and has atypical radiology manifestations. The present study reported a case of adult supratentorial ETMH misdiagnosed as glioblastoma preoperatively. By summarizing its clinical features, radiological manifestations, differential diagnosis, and treatment and reviewing relevant literature, the present study aimed to improve the understanding of the diagnosis and treatment of adult supratentorial ETMH.

Introduction

Embryonal tumor with medulloblastoma-like histopathology (ETMH) is an embryonic-type malignancy originating from remnants of primitive embryonic cells and is most common in children, accounting for 20% of all childhood central nervous system (CNS) tumors. It is rare in adults, where ETMH accounts for <1% of adult CNS tumors (1). Adult ETMH is prevalent in the cerebellar hemispheres and cerebellar vermis, and adjacent to the surface of the brain or the cerebellar tentorium (2). Adult supratentorial ETMH is extremely rare and has atypical clinical manifestations, which have been rarely reported in the literature. The radiological manifestations are atypical, making diagnosis difficult (3). The present study reported on the diagnosis and treatment processes of an adult patient with ETMH, which was misdiagnosed as glioblastoma multiforme (GBM) and a combined literature review analysis was provided to offer a reference for the diagnosis and treatment of this disease.

Case description

A 41-year-old male patient from Xuzhou visited The Second Affiliated Hospital of Xuzhou Medical University (Xuzhou, China) in August 2023, due to headache, nausea and vomiting for over a month. The symptoms worsened the week before visiting the hospital, without an obvious cause. The patient was otherwise healthy with no history of surgery, hypertension or family history. Physical examination and laboratory tests revealed no abnormalities. The patient underwent non-contrast and contrast-enhanced brain magnetic resonance imaging (MRI) (Fig. 1A-F), which revealed a cystic-solid lesion in the left frontal lobe with unclear borders, measuring ~60x50x39 mm. The lesion had a large central cyst and multiple small cysts at the margins. The solid part of the lesion exhibited hypointensity on T1-weighted imaging (T1WI), hyperintensity on T2-weighted imaging (T2WI), and inhomogeneous hyperintensity on diffusion-weighted imaging (DWI). The cystic part exhibited hypointensity on T1WI, hyperintensity on T2WI, and hypointensity on DWI. Contrast-enhanced T1WI (CE-T1WI) revealed obvious enhancement of the solid part of the lesion, with no enhancement of the cystic part. The periphery of the lesion presented with large areas of edema, marked compression and narrowing of the bilateral ventricles, and a rightward shift of the midline structures.

Diffusion tensor imaging (DTI) disclosed sparse and locally interrupted conduction bundles in the white matter of the left frontal lobe compared with the healthy side (Fig. 2A-C).

Magnetic resonance spectroscopy (MRS) of the left frontal region of interest (solid portion) revealed markedly elevated choline (Cho), decreased N-acetyl-aspartic acid (NAA) and creatine (Cr), and mildly elevated lactate (Lac) (Fig. 2D).

Based on the radiological findings, including: i) Marked enhancement of the solid part of the lesion, with absence of enhancement of the cystic part; ii) The periphery of the lesion presented with extensive perilesional edema; iii) DTI disclosed sparse and focally disrupted fiber tracts in the white matter of the left frontal lobe compared with the healthy side; iv) MRS of the left frontal region of interest (solid portion) revealed markedly elevated Cho, decreased NAA and Cr and therefore a diagnosis of GBM was made.

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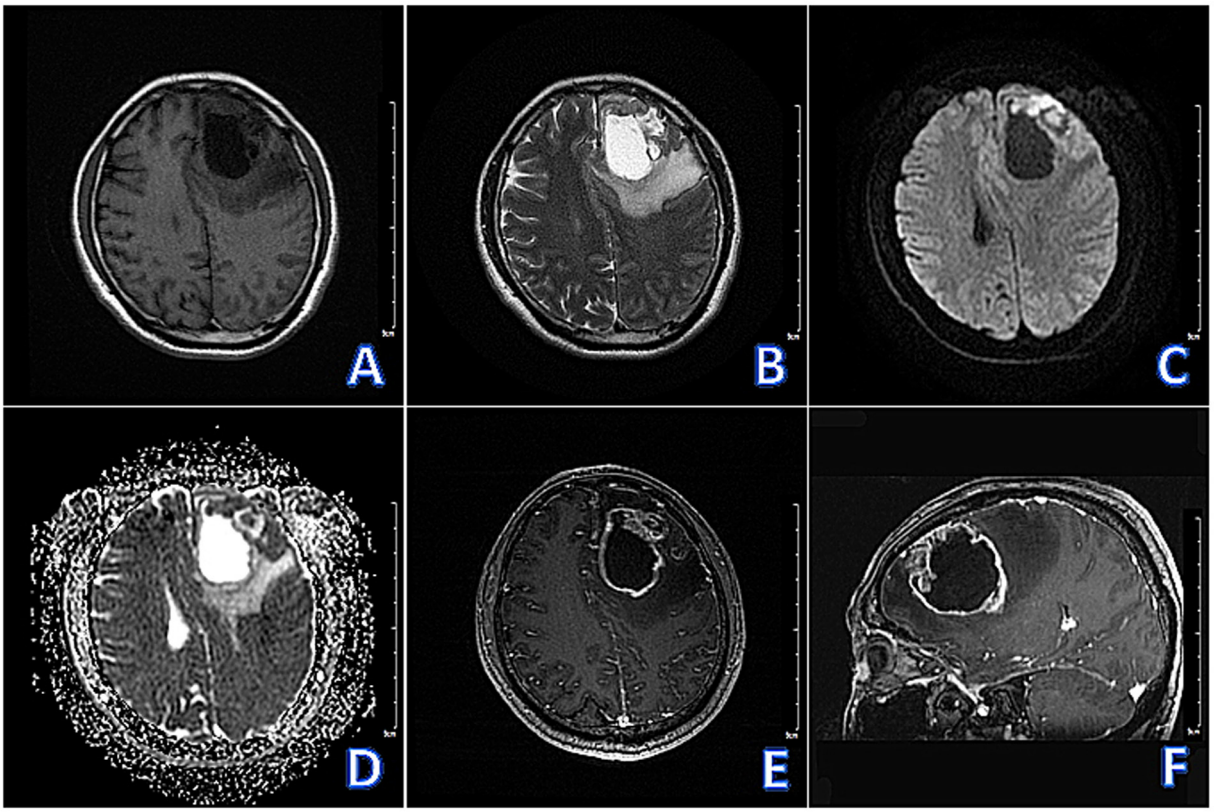

Figure 1. Pre-operative brain magnetic resonance imaging examinations. (A-F) Sequentially, T1WI (axial), T2WI (axial), DWI (axial), apparent diffusion coefficient (axial), CE-T1WI (axial), CE-T1WI (sagittal) revealed: Cystic solid occupancy in the left frontal lobe with unclear borders, with a large capsule in the center of the lesion and multiple small capsules at the margins. The solid part of the lesion showed hypointensity on T1WI, hyperintensity on T2WI, and inhomogeneous hyperintensity on DWI and the cystic part showed hypointensiy on T1WI, hyperintensity on T2WI and hypointensity on DWI. CE-T1WI showed obvious enhancement of the solid part of the lesion and no enhancement of the cystic part. The periphery of the lesion showed large areas of edema, with marked compression and narrowing of the bilateral ventricles and a rightward shift of the midline structures. T1WI, T1-weighted imaging; T2WI, T2-weighted imaging; DWI, diffusion-weighted imaging; CE, contrast-enhanced.

The patient underwent a left frontal lobe tumor resection in August 2023. Intraoperative findings revealed that the left frontal lobe tumor was grayish-white, soft, and cystic-solid, with a fish-like wall of the cystic portion, rich in blood supply, measuring ~60x55x40 mm, with unclear boundaries with the surrounding brain tissue. The tumor and part of the meninges were resected under the microscope.

Pathological examination. H&E staining revealed that the tumor component of the sent tissue consisted of round and oval cells with deeply stained nuclei and multiple chrysanthemum-shaped mass structures were exhibited (Fig. 3A).

Immunohistochemistry (IHC). The following findings were revealed in Fig. 3B-F: GFAP (focally +), S-100 (-), Olig-2 (+), ATRX (-), IDH-1 (-), P53 (~50% +), EMA (focally +), TP53 (-), NSE (-), Syn (focally +), CgA (-), CD56 (-), TIF-1 (-), Vimentin (focally +), CK (P) (-). Combined with H&E staining and IHC, the final pathological diagnosis was embryonal tumor, CNS WHO grade 4.

Postoperative follow-up non-contrast and contrast-enhanced brain MRI disclosed postoperative changes in the left frontal lobe, measuring 46x44x35 mm, with hypointensity on T1WI and uneven hypointensity on T2WI. The internal portion of the lesion presented with patchy hyperintensity on T1WI and T2WI (considering hemorrhage), and CE-T1WI revealed no enhancement within the lesion and irregular circumferential enhancement at the margins (Fig. 4A-F).

The patient underwent a cerebrospinal fluid (CSF) examination after surgery, and the result was negative. The patient was treated with anti-infective, hemostatic, acid-suppressive, antiepileptic, dehydration, brain recovery, and symptomatic supportive therapy.

After discussion by the neuro-oncology multidisciplinary team, the patient underwent craniospinal radiotherapy (RT) for a total dose of 35 Gy in conventional fractionation plus a sequential boost to residual surgical region for a total dose of 54 Gy.

Follow-up contrast-enhanced brain MRI one month after completion of RT revealed irregular circular enhancement in the operative region, measuring 29x28x21 mm. The rest of the brain exhibited no obvious abnormal enhancement and the edema around the lesion was less extensive than before, with the midline structure roughly centered (Fig. 4G-I).

The timeline for the patient's diagnosis and treatment is demonstrated in Fig. 5.

Discussion

ETMH is an embryonic malignant tumor originating from residual primitive embryonic cells, commonly found in children, accounting for 20% of all CNS tumors in children. A

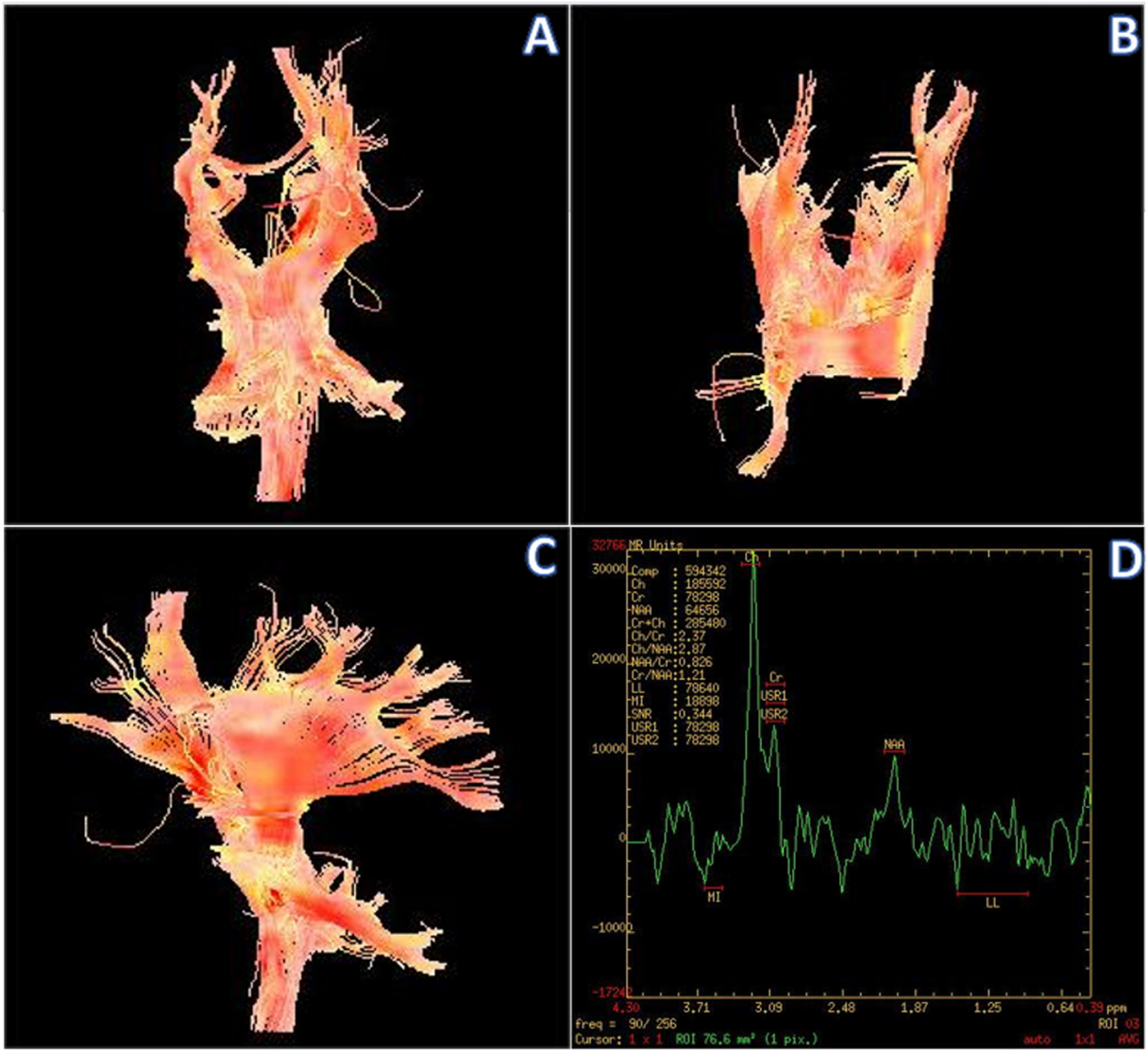

Figure 2. Pre-operative brain magnetic resonance imaging examinations. (A-C) Diffusion tensor imaging revealed: Sparse and locally interrupted conduction bundles in the white matter of the left frontal lobe compared with the healthy side. (D) Magnetic resonance spectroscopy on left frontal region of interest (solid portion) revealed: Cho was markedly elevated, NAA and Cr were decreased, and lactate was mildly elevated. Cho, choline; NAA, N-acetyl-aspartic acid; Cr, creatine.

total of 70% of ETMH occurs in children under the age of 10. ETMH is relatively rare in adults, accounting for <1% of adult CNS tumors, with the peak age of onset between 30-40 years old, and it is more common in male patients (1-4). ETMH often occurs in the posterior cranial fossa, with strong invasiveness, high malignancy, rapid growth, easy detachment of tumor cells, and the ability to produce disseminated implants along the subarachnoid space through CSF circulation. Therefore, the prognosis is poor and the survival period is short (5-7).

ETMH in children is most often observed in the midline, with ~28% occurring in the cerebellar vermis, more than half located in the dorsal cerebellar hemisphere near the pons and a few may be located in the pontocerebellar horn region (8-10). Adult ETMH is more common in the cerebellar hemisphere and vermis, closely attached to the surface or tentorium of the brain, with the most common clinical symptoms being headache, vomiting, unstable gait, ataxia and reduced vision (11). A study summarized the MRI manifestations of adult ETMH occurring in the cerebellum, as follows: The tumor was circular or quasi circular and could be multiple, prone to cystic changes, often located inside or around the lesion; the solid part of the tumor presented with hyperintensity on DWI, with uneven mild to moderate enhancement and no or mild peritumoral edema (12).

Adult supratentorial ETMH is extremely rare and has been rarely reported in the literature. The patient described in the present case report is a 41-year-old male with a cystic-solid lesion located in the left frontal lobe. The solid part disclosed hypointensity on T1WI and hyperintensity on T2WI and the solid component of the lesion was significantly enhanced on contrast-enhanced T1WI. MRS and DTI indicated that the lesion was an intracerebral lesion with damage to the white matter fiber bundle and the surrounding edema range was wide. Similar to the radiological manifestations of the case reported by Hou *et al* (13), the difference is that the surrounding edema range is larger in the present case.

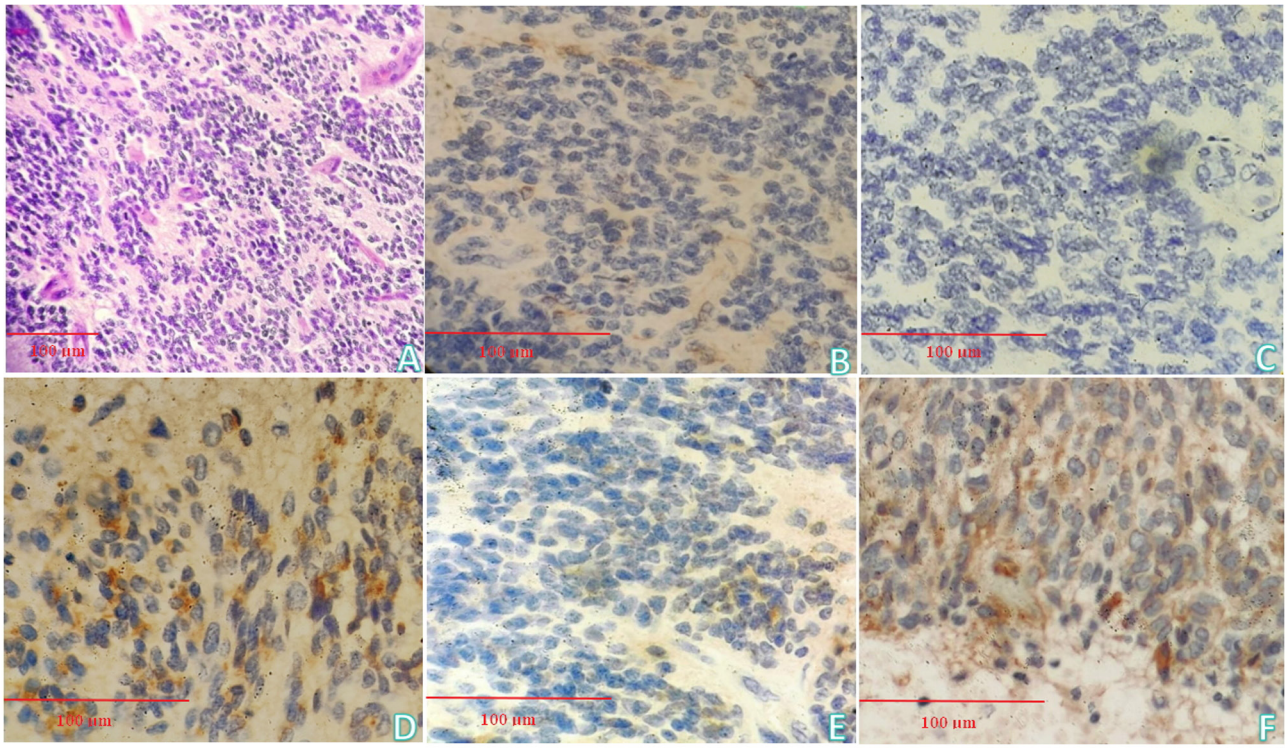

Figure 3. Pathological examination. (A) H&E staining (x200) revealed that the tumor component of the sent tissue consisted of round and oval cells with deeply stained nuclei, and multiple chrysanthemum-shaped mass structures were observed. (B-F) Immunohistochemistry (magnification, x400): Sequentially, GFAP (focally +), Olig-2 (+), EMA (focally +), Syn (focally +), Vimentin (focally +).

The preoperative diagnosis of this case was GBM and the possibility of ETMH was not considered. Summarizing the causes of misdiagnosis in the present case may include the following points. First, combining the patient's clinical symptoms and radiological manifestations, common supratentorial brain tumors were preferred and the imaging features of the lesion in the present case were more consistent with GBM. Second, adult ETMH is relatively rare and lacks a characteristic radiological presentation and radiologists lack experience in the diagnosis of this disease. Furthermore, adult ETMH occurs more often in the cerebellum and less often in the supratentorial region, whereas in this case the lesion was located in the left frontal lobe in an atypical location, which makes it highly susceptible to misdiagnosis (14).

Reviewing the present case and referring to the relevant literature, it was hypothesized that the present case still has the characteristic radiological presentation of ETMH (15-17): i) The solid part of the lesion presented with obvious hyperintensity on DWI and hypointensity on apparent diffusion coefficient (ADC). The pathological basis is that ETMH is a tumor of small round-cell origin and the tumor cells are densely arranged, with little cytoplasm, large and densely stained nuclei, high nuclear-to-plasma ratio, small extracellular interstitial space, and the tumor contains little water and the diffusion of water molecules is significantly restricted, which mostly showed hyperintensity on DWI and the corresponding ADC value is reduced. ii) There are cystic and necrotic areas within the tumor. Cystic changes are a relatively typical radiological sign of ETMH and the rate of cystic changes can exceed 80% (18). The cause may be related to the lack of blood supply in the fast-growing tumor or the presence of some secretory function of the tumor. iii) The solid part of the lesion has significantly elevated Cho, significantly decreased NAA, significantly increased Cho/Cr and Cho/NAA ratios and mildly elevated and partially inverted Lac, suggesting a high degree of tumor malignancy as well as a mild hypoxic state. Although MRS does not make the diagnosis of ETMH alone, it assists in differentiating it from extracerebral tumors.

Key imaging features of adult supratentorial ETMH include (19): i) CT: Ill-defined supratentorial mass with heterogeneous density, occasionally showing calcifications or necrosis. ii) MRI: Iso-to hypointense on T1WI, heterogeneous hyperintensity on T2/FLAIR sequences with surrounding vasogenic edema and restricted diffusion due to high cellularity. iii) Contrast enhancement: Moderate to marked heterogeneous enhancement, often with rim enhancement in cystic areas. iv) MRS: Cho peak, reduced NAA and possible lactate/lipid peaks, reflecting aggressive metabolism. In addition, adult supratentorial ETMH needs to be differentiated from the following tumors: i) GBM: GBM is prevalent in middle-aged and elderly people, often located in the white matter of the cerebral hemisphere. It is irregular in shape, with hypointensity on T1WI and hyperintensity on T2WI, and is mostly inhomogeneous and prone to necrosis. The tumor has infiltrative growth, with an unclear boundary, and the solid part of the tumor is often mildly diffusion restricted on DWI (degree of restriction lower than that of ETMH). Surrounding the tumor is often accompanied by extensive edema, and CE-T1WI reveals a wreath-like enhancement (20). ii) Ventricular meningioma (VM): Cystic-solid parenchymal VM often occurs in children or adolescents, and the all-parenchymal type is more common in adults. The tumor is located in the frontoparietal

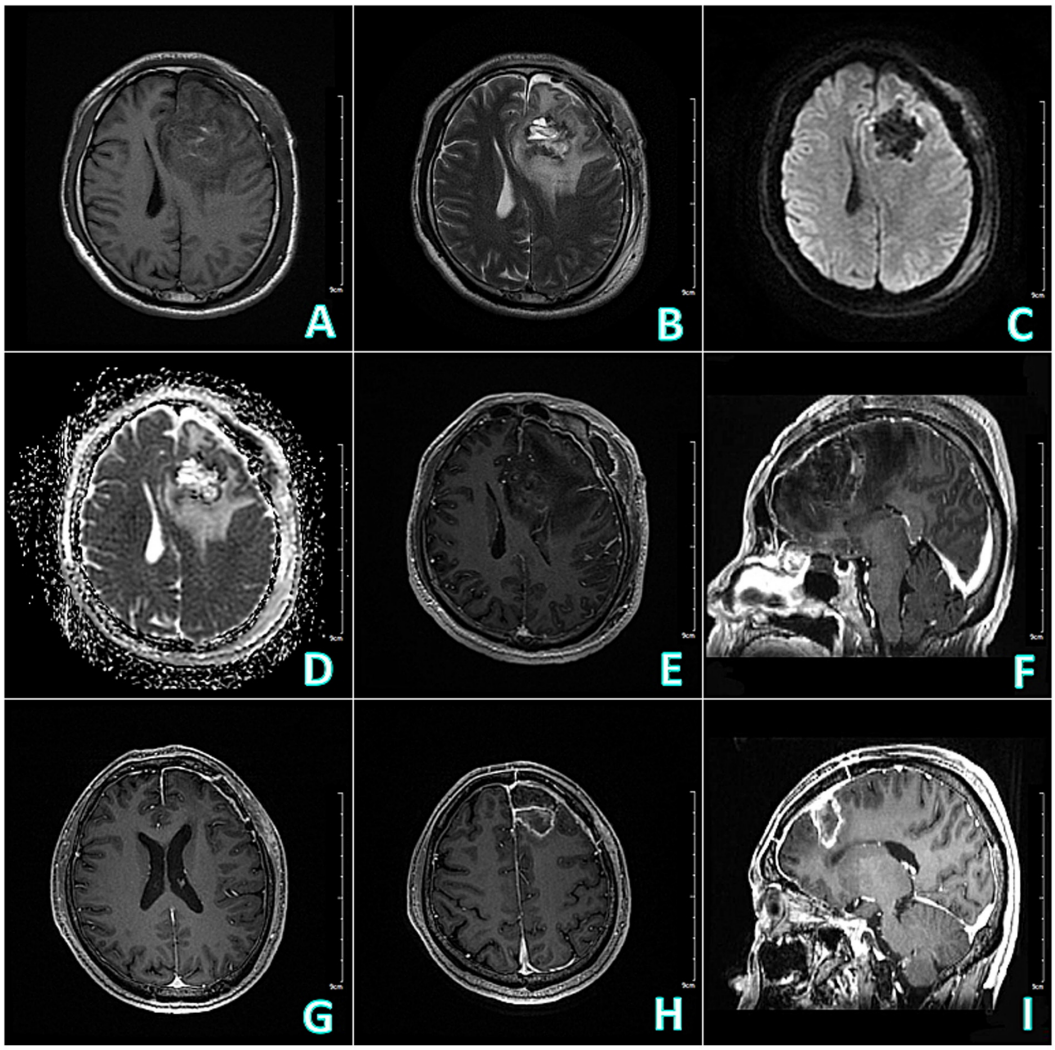

Figure 4. Follow-up brain MRI of postoperative and completion of RT. (A-F) Postoperative brain MRI: Sequentially, T1WI (axial), T2WI (axial), DWI (axial), apparent diffusion coefficient (axial), CE-T1WI (axial), CE-T1WI (sagittal) showed that postoperative changes in the left frontal lobe, 46x44x35 mm in size, with hypointensity on T1WI and uneven hypointensity on T2WI, and the internal portion of the lesion showed patchy hyperintensity on T1WI and T2WI (considering hemorrhage), and CE-T1WI revealed no enhancement within the lesion and irregular circumferential enhancement at the margins. (G-I) Follow-up contrast-enhanced brain MRI one month after completion of RT: Sequentially, CE-T1WI (axial), CE-T1WI (axial), CE-T1WI (sagittal) revealed that irregular circular enhancement in the operative region, measuring 29x28x21 mm, and the edema around the lesion was less extensive than before (postoperative), and the midline structure was roughly centered. MRI, magnetic resonance imaging; RT, radiotherapy; T1WI, T1-weighted imaging; T2WI, T2-weighted imaging; DWI, diffusion-weighted imaging; CE, contrast-enhanced.

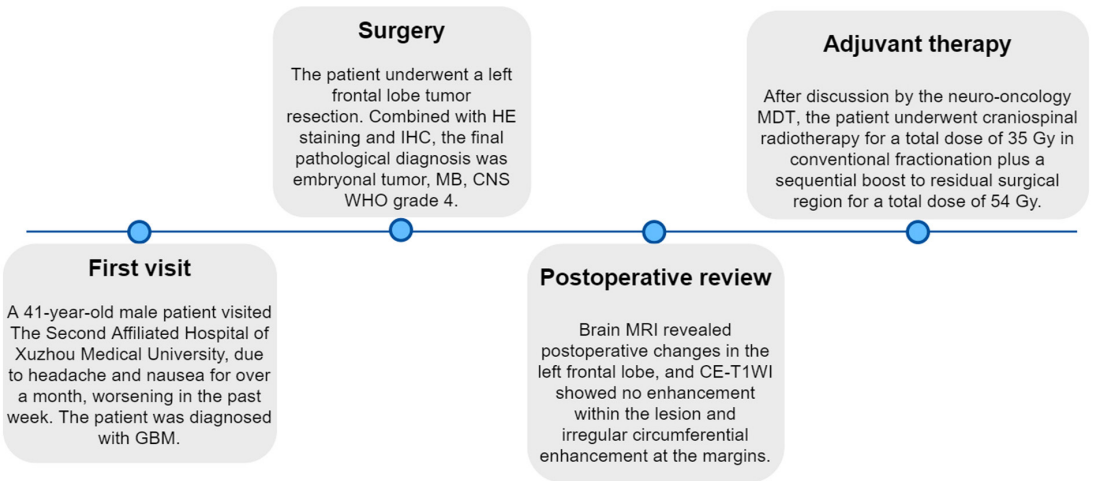

Figure 5. Timeline for patient diagnosis and treatment. GBM, glioblastoma multiforme; IHC, immunohistochemistry; CNS, central nervous system; MRI, magnetic resonance imaging; T1WI, T1-weighted imaging; MDT, multidisciplinary team.

lobe, with uneven intensity, often combined with necrosis, cystic degeneration, or calcification. The cystic portion often accounts for >2/3 of the tumor, and the cystic wall is thin. The solid portion is mostly located in the cortical area. The tumor shows mild diffusion restriction on DWI with no peritumoral edema, and the solid part of the lesion presents with obvious enhancement on CE-T1WI (21). iii) Solitary brain metastasis (SBM): SBM is common in middle-aged and elderly people with a history of primary tumor. SBM is often located in the corticomedullary junction area, and the radiological manifestations vary depending on the primary tumor. SBM is prone to hemorrhage and necrosis, often showing irregular ring enhancement and peritumoral edema is more obvious (22). iv) Primary CNS lymphoma (PCNSL). PCNSL is located in the white matter area, with irregular morphology and can grow across the midline via the *corpus callosum*. The intensity of PCNSL is mostly uniform, presenting is equal intensity on T1WI and T2WI, obviously diffusion-restricted on DWI, with obvious surrounding edema, and homogeneous and obvious enhancement on CE-T1WI. Besides, the presence of Lac and Lip, together with the elevation of the Cho/Cr ratio, are of great value in the diagnosis of PCNSL (23). v) Meningioma*:* Meningiomas are more common in female patients and often have calcification. There are often signs of extracerebral tumors such as compression and displacement of brain parenchyma, widening of brain cisterns, and bone changes in the cranium. MRS can distinguish whether tumors are intracerebral or extracerebral and has differential value (24).

Adult ETMH is relatively rare, with fewer prospective studies in adults, and most current diagnostic protocols refer to advances in pediatric ETMH. Surgical resection is preferred for this disease, but complete resection is generally difficult. The principles are to achieve maximum resection of the tumor under the premise of minimizing damage to normal brain tissue and re-establishing the CSF circulation (25,26). ETMH is prone to CNS metastasis, and postoperative craniospinal RT and/or chemotherapy (CMT) is the standard treatment for this disease. RT/CMT should be administered as early as possible after tumor resection, and the ideal time to start RT/CMT is within 4-6 weeks postoperatively. The patient's age, the extent of surgical resection, the postoperative physical condition, the presence or absence of metastasis on radiological examinations, the results of the CSF examination, and the type of postoperative pathology should be adequately evaluated prior to RT/CMT, and different therapeutic strategies should then be adopted according to the clinical risk stratification (27,28). Although comprehensive treatment with surgery as the mainstay and RT and CMT as adjuncts has made some progress, the prognosis of ETMH patients remains poor, and surviving patients are still affected by serious adverse reactions. In recent years, with the development of genomics, people have gained a deeper understanding of the molecular typing and development mechanisms of ETMH, and targeted therapy has become a new research hotspot. Accurate molecular typing and personalized targeted treatment strategies may improve the overall survival and quality of life of patients with ETMH (29,30).

The molecular subtypes of ETMH can be divided into four types, namely WNT type, SHH type, Group 3, and Group 4. WNT type is defined as low-risk and can reduce the radiation dose during RT. Chemotherapy regimens mainly include cisplatin and cyclophosphamide to avoid overtreatment. Group 4 is of moderate risk, with a treatment plan consisting of standard chemotherapy (cisplatin, vincristine) and conformal RT. Group 3 is defined as high-risk and requires intensive treatment (high-dose RT combined with multi drug chemotherapy). SHH type is recommended for targeted therapy, using SMO inhibitors or PI3K/mTOR inhibitors (31). The patient was recommended to undergo more comprehensive molecular examinations, however he and his family refused due to the high cost. The cost of tumor molecular examination is expensive, which cannot be reimbursed by medical insurance and needs to be borne by patients themselves.

In clinical practice, when adults present with solid cystic lesions in the supratentorial brain that are difficult to distinguish from GBM, clinicians also need to pay attention to the characteristics of DWI and ADC intensities in the lesions, as well as whether there are cystic changes and necrosis. When the lesions show obvious hyperintensity in the solid part of DWI and obvious hypointensity in ADC, and there are cystic changes and necrosis, especially when multiple cystic lesions appear, the diagnosis of ETMH should be considered (32,33).

First and foremost, enhancing the recognition capability of ETMH in rare screenings and minimizing misdiagnosis is crucial. This involves refining the diagnostic techniques and algorithms to improve identification of the unique characteristics of ETMH even in less common imaging presentations. Secondly, standardizing the application of multimodal imaging and molecular detection is essential. By integrating different imaging modalities such as MRI, CT, and PET-CT, along with advanced molecular tests, a more comprehensive understanding of the tumor can be obtained, thereby facilitating accurate diagnosis. This standardization should cover aspects including the sequence of tests, interpretation criteria and data integration. Moreover, optimizing treatment strategies, including precisely defining the RT range and dosage, holds the key to improving patient prognosis. Tailoring the treatment according to the individual patient's condition, tumor size, location, and genetic profile can maximize the therapeutic effect while minimizing side-effects (34).

The original intention of the present study was to reveal the clinical characteristics of adult supratentorial ETMH through typical cases, providing reference for clinical practice. However, the authors realized that relying solely on individual case data is difficult to support innovative conclusions. Although lacking in innovation, the present study systematically summarized the imaging and clinical characteristics of adult supratentorial ETMH, providing a standardized evaluation tool for subsequent large-scale studies. Connections with other hospitals will be established to collect more cases of this kind, laying the foundation for future innovative research.

WHO 2021 Classification of Tumors of the CNS has redefined embryonal tumors based on molecular characteristics, where traditional anatomical locations are no longer the primary basis for classification. According to the review by Louis *et al* (35), ETMH is now classified as an 'embryonal tumor', and its diagnosis requires integration of molecular subtypes (for example, WNT, SHH, Group 3/4). The IHC results in the present case suggested a neurogenic embryonal

tumor; however, the limitation of lacking molecular subtyping data to confirm the specific subtype was acknowledged. In developing countries, molecular testing is prohibitively expensive, and numerous patients decline such testing due to financial constraints, leading to limited adoption of the WHO 2021 classification criteria. In future clinical practice, the authors will strengthen patient education to emphasize the importance of molecular subtyping in diagnosing such tumors and recommend comprehensive molecular testing for eligible patients.

In summary, adult ETMH is rare, and those occurring in the supratentorial region are even rarer. The radiological manifestations are atypical, and diagnosis is difficult. However, conventional MRI, DWI and MRS findings still have certain diagnostic value. Therefore, when adults are found to have supratentorial tumors that differ from common tumor radiological manifestations, multimodal MRI methods should be applied to improve diagnostic accuracy, improve assistance in the formulation of clinical treatment plans and evaluate prognosis. For the diagnosis of supratentorial cystic-solid tumors, the possibility of ETMH should be considered.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

YW, AC and PD conceived and designed the study, collected and assembled the data, and confirm the authenticity of all the raw data. All authors read and revised the manuscript. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

The present study involving human participant was reviewed and approved (approval no. 2024032703) by the Ethics Committee of The Second Affiliated Hospital of Xuzhou Medical University (Xuzhou, China) The patient provided his written informed consent to participate in the present study.

Patient consent for publication

The patient provided informed consent for publication of his data and associated images.

Competing interests

The authors declare that they have no competing interests.

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