MR Finding of Extraventricular Neurocytoma

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ABSTRACT

Objective: To determine the MR (magnetic resonance), pathologic, and clinical findings of extraventricular neurocytoma (EVN).
Study Design: Descriptive study.
Place and Duration of Study: Department of Radiology, Affiliated Hospital of Jining Medical University, Jining, Shandong, China, from January 2020 to March 2022.
Methodology: The MR radiological and pathological data of 11 patients with EVNs proved by histopathology after surgery were analysed retrospectively. Above-mentioned features were studied.
Results: There were 5 men and 6 women, ages ranging from 16 to 56 years. Seven cases (63.6%) were located in the cerebral hemisphere, three cases (27.3%) in the cerebellar hemisphere, and one case in cervical cord. Ten cases (91.0%) were cystic--solid, and one case was predominantly solid with small cystic components. Six cases (54.5%) had mild peritumoural ooedema. The signal was isointense (8/11, 72.7%) or hypointense (3/11, 27.3%) on T1WI, and isointense (1/11, 9.1%) or hyperintense (10/11, 90.9%) on T2WI; all cases showed hyperintense on FLAIR and restricted diffusion on DWI. Haemorrhage was found in two cases (18.2%) and flow-void was found in one case (9.1%). All the tumours demonstrated contrast enhancement.
Conclusion: An accurate diagnosis of EVN is difficult to be made preoperatively. It should be considered when a solid-cystic tumour with the solid part showing isointense on T1WI, hyperintense on FLAIR with mild to moderate enhancement especially restricted diffusion on DWI sequence in patients aged 20-30. When the radiologic manifestations are atypical, more aggressive treatment should be chosen.

Key Words: *Neurocytoma, Extraventricular, Clinical, Imaging characteristics, MRI.*

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INTRODUCTION

Extraventricular neurocytoma (EVN) is an exceeding rare tumour arising from extra ventricular parenchymal tissue, the incidence rate was 0.009 per 100,000 population.[1,2] The biological and histopathological characteristics of EVN were similar to central neurocytoma (CN) but with more aggressive behaviour than CN.[3] The tumour was first described in 1989.[4] In 2016 WHO classification of tumours of the central nervous system (CNS), it was classified as an entity tumour with Diseases-code (9506/1) and histologically corresponds to WHO grade II.[5] MRI plays an important role in the diagnosis of CNS tumour preoperatively.

However, the MRI features of EVN were reported in a few reports with limited cases. Owing to an insufficient understanding of its MRI characteristics, EVN was mostly misdiagnosed as other intracranial tumours.

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The objective of this study was to document the diagnostic, pathological, and MRI characteristics of EVN.

METHODOLOGY

This study was approved by the Institutional Review Board of the Affiliated Hospital of Jining Medical University, Jining, Shandong, China, (2020C049). Patients diagnosed with ENV at the institution, from January 2012 to May 2019, were collected retrospectively. All subjects had undergone a complete brain MRI including plain and enhanced scanning and confirmed by surgery and histopathology. Patients with history of biopsy, preoperative radiotherapy, and other diffuse intracerebral diseases were excluded. Eleven patients with ENV were enrolled in this study. The clinical manifestations, MR images, and pathological findings of the 11 patients were reviewed retrospectively.

All the patients underwent pretreatment MR scan, using a 3.0T MRI scanner (Philips Medical Systems, Best, Netherlands) with a sixteen-channel head coil. The sequences included axial T1-weighted (TR=2000 ms; TE=20 ms), T2-weighted (TR=3000 ms; TE=80 ms), FLAIR (TR=11000 ms; TE=125 ms; inversion time=2200 ms). Gadolinium contrast-enhanced T1-weighted were also obtained after a contrast agent (Gd-DTPA; 0.2 ml/kg body weight; Magnevist; Bayer Schering, Guangzhou, China) was injected. The field of view was 240×240 mm^2, the matrix was 512×512, and the slice thickness was 5 mm. Moreover, diffu-

sion-weighted imaging was performed before the gadolinium contrast-enhanced T1-weighted sequence, using a multislice single-shot echo-planar imaging sequence (TR=5900 ms; TE=96 ms) with b values of 0 and 1000 s/mm^2, the field of view was 240×240 mm^2, the matrix was 128×128, and the slice thickness was 5 mm without the gap.

Two experienced neuroradiologists reviewed the MR images. The MRI features, including location, tumour volume [tumour volume=length×(width^2)/2],[6] internal architecture, margin, peritumoural oedema (using oedema index describe, EI=$V_{tumour+oedema}/V_{tumour}$),[7] signal intensity and characteristics of enhancement were assessed. One neuropathologist reviewed the tumour specimens stained by Hematoxylin-Eosin and stained immunohistochemical by antibodies against Synaptophysin (Syn), and Ki-67.

Data were analysed using statistical software (SPSS, version 22.0, IBM). Shapiro-Wilk statistical test was used to assess the normality. Continuous variables with normal distribution were expressed as mean and standard deviation, continuous variables with skewed distribution were expressed as median and range, and the frequency of clinical characteristics and MR signs were expressed as the number (percentage) of occurrences.

RESULTS

The clinical manifestations, MR images and pathological findings of the 11 patients were reviewed retrospectively. The mean age of patients was 33.36 (14.3) years and the median duration of tumours was 20 (IQR:31) weeks. The demographic, clinical treatment, pathology and follow-up data of the 11 patients with EVN were summarised in Table I.

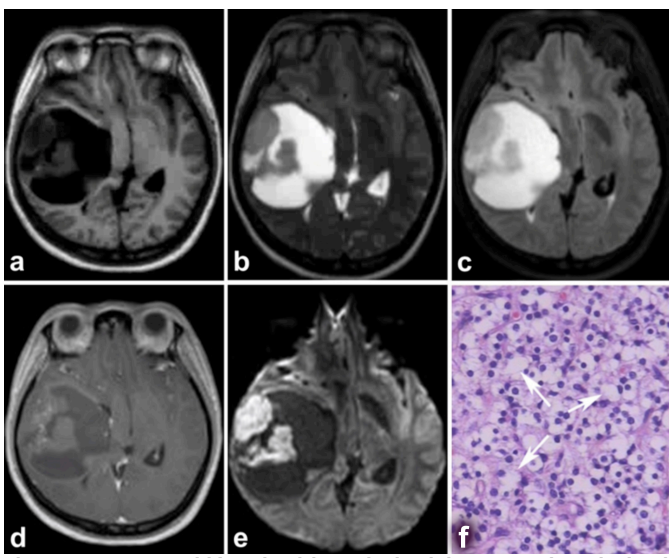

Figure 1: A 26-year-old female with EVN in the right temporalp and arietal lobe. Axial T1WI (a) and T2WI (b) showed a well-demarcated and cystic--solid mass without peritumour al oedema. The solid part showed slight hypointense on T1WI and hyperintense on T2WI. Axial FLAIR (c) the cystic part showed hyperintense. Axial postcontrast T1WI (d), the solid part showed mild enhancement. On DWI-MRI (e) the solid part showed marked restricted diffusion. Hematoxylin and eosin-stained section (f) showed multiple cystic areas (white arrow).

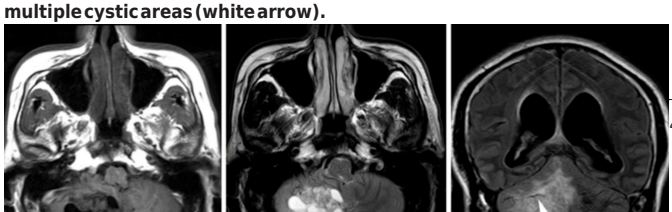

Figure 2: A 38-year-old female with EVN in the right cerebellar hemisphere. Axial T1WI (a) and T2WI (b) showed a well-demarcated and cystic--solid mass with slightly peritumour al oedema. The solid part showed slight hypointense on T1WI and hyperintense on T2WI, "flow-void" vessel was seen (white arrow). Coronary FLAIR (c) showed a "flow-void" vessel. Axial postcontrast T1WI (d) the solid part showed marked enhancement. Hematoxylin and eosin-stained section (e) showed cystic areas (black arrow) and multiple microvascular (red arrow). Immunohistochemical section (f) tumour cells show marked diffuse Syn.

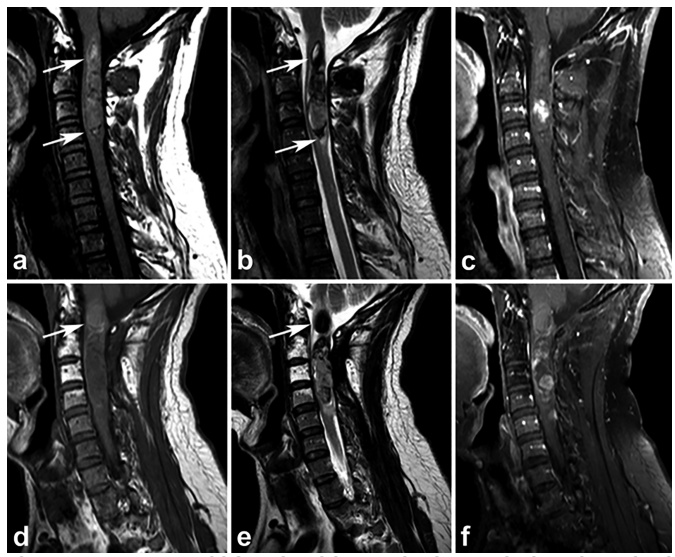

Figure 3: A 50-year-old female with EVN, in the cervical cord. Sagittal T1WI (a) and T2WI (b) showed an ill-demarcated and solid mass with slightly peritumour al oedema, the mass showed isointense on T1WI and hyperintense on T2WI, with hyperintense on T1WI and significant hypointense due to haemorrhage (white arrow). Sagittal postcontrast T1WI (c) part of the mass showed marked enhancement. Sagittal T1WI (d), T2WI (e) and postcontrast T1WI (f) showed tumour recurrence re-examination 5 months after STR and RT, the haemorrhage was seen (white arrow).

The details of MRI characteristics were summarised in Table II. Seven lesions (63.6%) were located in the cerebral hemisphere (Figure 1), three (27.3%) in the cerebellar hemisphere (Figure 2) and one in the spinal cord (Figure 3). The median volume of the lesions was 22.82×103 mm^3, ranged from 4.75×103 mm^3 to 105.84×103 mm^3. Ten cases (91.0%) were cystic-solid and one case was solid with small cysts in it.

Table I: The demographic, clinical treatment, pathology and follow-up data of the eleven patients with EVN.

Case	Age	Gender	Symptoms	Duration time	Location	Surgical excision	Adjuvant Therapy	Ki-67	Follow-up after surgery
1	16	F	Headache and seizures	4 Weeks	Left frontal	GTR	NO	2%	No recurrence at the 47th month
2	20	M	Headache and dystaxia	12 Weeks	Left cerebellar hemisphere	GTR	RT	3%	No recurrence at the 36th month
3	23	F	Headache and seizures	5 Weeks	Left frontal	GTR	RT	5%	Recurrence at the 48th month
4	24	M	Headache	40 Weeks	Right frontal	GTR	RT	3%	No recurrence at the 48th month
5	26	F	Headache and vomiting	1 Weeks	Right temporal and parietal	GTR	RT	2%	No recurrence at the 60th month
6	27	F	Headache and visual abnormality	20 Weeks	Right parietal and occipital	GTR	NO	2%	No recurrence at the 14th month
7	32	F	Headache and facial numb	32 Weeks	Right temporal	GTR	RT	8%	Recurrence at the 17th month
8	38	F	Headache and dystaxia	28 Weeks	Right cerebellar hemisphere	GTR	RT	5%	No recurrence at the 24th month
9	50	M	Neck discomfort and limb numbness	16 Weeks	Cervical cord	STR	RT	7%	Recurrence at the 5th month
10	55	M	Headache and dystaxia	36 Weeks	Right cerebellar hemisphere	GTR	RT	3%	No recurrence at the 24th month
11	56	M	Headache	92 Weeks	Left frontal	GTR	Refuse	2%	No recurrence at the 72nd month

F, Femal; M, Male; GTR, Gross total resection; STR, Subtotal resection; RT, Radiotherapy.

Table II: The details of MRI characteristics of the eleven patients with EVN.

Case	Location	Volume (mm^3)	Pattern	Margin	EI	Haemorrhage	Flow-void	MR T1WI	FLAIR	DWI	Enhancement
1	Left frontal	4752	Cystic-solid	Ill-defined	1.2	-	-	Isointense	Hyperintense	Hyperintense	Moderate
2	Left cerebellar hemisphere	10881	Cystic-solid	Well-defined	1	-	-	Isointense	Hyperintense	Hyperintense	Mild
3	Left frontal	105840	Cystic-solid	Ill-defined	2.8	+	-	Isointense	Hyperintense	Hyperintense	Marked
4	Right frontal	83809	Cystic-solid	Well-defined	1.4	-	-	Isointense	Hyperintense	Hyperintense	Moderate
5	Right temporal and parietal	85224	Cystic-solid	Well-defined	1	-	-	Isointense	Hyperintense	Hyperintense	Mild
6	Right parietal and occipital	12420	Cystic-solid	Well-defined	1.2	-	-	Hypointense	Hyperintense	Hyperintense	Moderate
7	Right temporal	22816	Cystic-solid	Ill-defined	2.6	-	-	Isointense	Hyperintense	Hyperintense	Moderate
8	Right cerebellar hemisphere	29260	Cystic-solid	Well-defined	1.1	-	+	Hypointense	Hyperintense	Hyperintense	Marked
9	Cervical cord	4758	Solid with small cystic	Ill-defined	1.1	+	-	Isointense	Hyperintense	Hyperintense	Marked
10	Right cerebellar hemisphere	20295	Cystic-solid	Ill-defined	1.3	-	-	Isointense	Hyperintense	Hyperintense	Moderate
11	Left frontal	42140	Cystic-solid	Ill-defined	1.4	-	-	Isointense	Hyperintense	Hyperintense	Moderate

EI, Oedema index; T1WI, T1-weighted imaging; DWI, Diffusion weighted imaging; FLAIR, Fluid-attenuated inversion recovery.

One case (9.1%) showed flow-void (Figure 2a-2c) and two cases showed haemorrhage (Figure 3a-3b). Five cases (45.5%) were well-demarcated and 6 cases (54.5%) with ill-demarcated margins. On MR images, the solid parts of the tumours manifested isointense (8/11, 72.7%) or hypointense (3/11, 27.3%) on T1WI, hyperintense (11/11, 100%) on T2WI, and hyperintense (11/11, 100%) on FLAIR. The cystic parts of the tumours showed hypointense (11/11, 100%) on T1WI, hyperintense (11/11, 100%) on T2WI, and hyperintense (11/11, 100%) on FLAIR. Eight cases (72.7%) displayed mild peritumour oedema (EI <1.5), and two cases (18.2%) had moderate peritumour oedema (1.5 ≤EI <3). On contrast-enhanced T1WI, solid parts of the tumour s showed mild enhancement in 2 cases (18.2%) (Figure 1d), moderate enhancement in 6 cases (54.4%), and marked enhancement in 3 cases (27.3%) (Figure 2d). All cases which underwent DWI, the solid part of the tumour showed hyperintense, which indicate marked restricted diffusion (Figure 1e).

Seven cases (63.6%) were composed of round to oval neoplastic cells with small regular, round nuclei, and the endothelial cell proliferations were mild (Figure 1f), and the Ki-67 index of them was less than or equal to 3%, respectively. Four cases (36.4%) were composed of cells with hyperchromatic nuclei which closely packed, and the endothelial cell proliferations were prominent, the Ki-67 index of them was more than 3%, respectively. Immunohistochemically, all of the 11 cases (100%) showed positive staining for Syn (Figure 2f).

DISCUSSION

According to the previous reports, EVN may occur in any age ranging from 2 to 76 years old, and frequently affects young adults during 20-34 years of age with no gender differences.[8] The above epidemiological characteristics of this series were consistent with these previous reports. The most common symptom of EVN was headache, followed by dystaxia and seizures. These clinical manifestations were

nonspecific as other intracranial tumours, mainly related to the size and location of the tumour. The duration of time from the onset of symptoms to diagnosis was shorter than previous report (32.5 months), which maybe related to the patients' habit of hospitalised behaviour.[9]

The most common location of EVN is the frontal lobe, followed by the cerebellar hemisphere.[10,11] The EVNs mainly appeared as soild or cystic-solid masses, also it can be totally cystic.[12] In this series, most lesions demonstrated cystic-solid. Reviewing the available studies on the MR imaging features of EVNs, Liu *et al*. found that the intracranial EVNs frequently present features such as well-demarcated margins, cystic degeneration, peritumoural oedema, calcification and haemorrhage.[8] The reported MR features were also present in this series, but there were some small differences. Five cases (45.5%) present a well-demarcated margin, 10 (91.0%) showed cystic degeneration, 7 (63.6%) showed peritumoral oedema, 2 (18.2%) revealed haemorrhage. In this series, the solid parts of EVNs mainly show isointensity or slightly hypointense on T1-weighted images and hyperintensity on T2-weighted images or FLAIR images, but the signal intensity might be affected by the unusual components, such as haemorrhage. On gadolinium-enhanced T1-weighted images, the solid parts and the cystic wall show enhancement with varies degree, including of mild, moderate, and marked, mainly depending on the content of the microvascular. This enhancement pattern was consistent with Jiang's report.[10] In addition, Jiang *et al*. also reported an extremely rare case of EVNs which had no enhancement. On the DWI image, all cases showed that the solid part of the tumour displayed restricted diffusion. No study assessing the performance of EVN on DWI has been found. Only one previous report has analysed the DWI appearance of CN[13] CN display restricted diffusion on DWI sequence, and DWI could be useful in the differential diagnosis of CN from other intracranial tumours. As the pathological characteristics of EVN were similar to CN, maybe the restricted diffusion on DWI could be used to distinguish EVN from other intracranial tumours.

Histopathologically, the tumour cells had round or oval nucleus and arranged in sheets, clusters, ribbons, or rosettes in nerve fibers. The cells had a tendency toward ganglionic differentiation, Brat considered that it might be the pathologic basis of EVNs degenerating into necrosis.[14] This speculation was confirmed by this series. Among the 10 cases of cystic-solid EVNs, the higher the proportion of ganglionic differentiation detected, the higher the proportion of cystic degeneration occurred. It is worth noting that the histopathological performance of EVNs was similar to that of oligodendrogliomas with neuronal characteristics.[8] Thus, immunohistochemistry, especially Syn, plays an important role in the differential diagnosis. In the present series, all of the 11 cases stained positive for Syn. It was consistent with the report of Sweiss.[11]

It was reported that the EVN cases with the Ki-67 index >3% were suggestive of atypical EVNs which could display aggressive behaviour.[11] Compared with the typical partner, the recurrence risk was 2-3-fold higher in atypical EVNs.[15] In this series, four cases (36.4%) could be referred to as atypical EVNs. Compared with typical partners, the atypical cases have some atypical radiologic features, the volume and EI were slightly larger, the margins were more likely ill-defined (4/4 vs. 2/7), and haemorrhage (2/4 vs. 0/7) or flow-void (1/4 vs. 0/7) might be found. In this series, all the 3 cases with tumour recurrence matched the diagnostic standard of atypical EVNs, supporting that atypical EVNs are associated with a poor prognosis. So, besides the pathologic features, the atypical radiologic features should be a clue to the diagnosis of the atypical EVN.

As other intracranial tumours, surgery is the first choice for the treatment of EVN. For the atypical EVN, the postoperative radiotherapy (RT) was still required in order to provide better control for tumour recurrence.[1,15] In this series, 7 cases (7/7, 100%) of typical EVNs did not recur till the follow-up time. Contrariously, 3 cases (3/4, 75%) of atypical EVNs showed recurrence. So, it is suggested that if the tumour is considered to be an atypical EVN, more aggressive treatment should be the choice.

As the EVN could display variety MRI manifestations, the differential diagnosis for EVN typically includes oligodendrogliomas and astrocytoma. Compared with EVN, oligodendrogliomas and astrocytoma often show an infiltrative appearance, the margin was ill-defined, and the solid parts mainly display hypointense on T1WI. Moreover, Oligodendrogliomas usually involve the adjacent cortical grey matter, forming an irregular gyriform ribbon and the calcifications of oligodendrogliomas are typically gyrus-like, and larger than the "dotted" calcifications encountered in EVNs.[8,12] For some cystic-solid type EVNs, they should be differentiated from gangliogliomas. In addition, some EVNs which only present as purely cystic should be distinguished from neuroglial cyst, the hyperintense signal of cystic part on FLAIR maybe suggested the diagnosis of EVN.[16]

This study had some limitations. First, only 11 cases were included in the study. This in part may reflect the relatively low prevalence of EVN in the general population. Second, the retrospective nature of this study precluded the use of other techniques such as perfusion-weighted imaging and magnetic resonance spectroscopy.

CONCLUSION

When a solid-cystic tumour shows isointense on T1WI, hyperintense on T2WI and FLAIR, and mild to moderate enhancement especially restricted diffusion on DWI sequence occurred in patients aged 20-30 years. EVN should be considered as a differential diagnosis. However, the accuracy-diagnosis still depends on histopathology and immunohis-

tochemistry. Moreover, if the Ki-67 index was more than 3%, or atypical radiologic features such as larger volume, peritumoural oedema, ill-defined and haemorrhage are present, there is a potential risk of poor prognosis.

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ETHICAL APPROVAL:
This study was conducted after approval from the institutional Review Board (2020C049).

COMPETING INTEREST:
The authors declared no competing interest.

AUTHORS' CONTRIBUTION:
SH, ZS, XL: Conception and design, drafting of the manuscript.
JZ, ZS, YC: Conception and design, acquisition of data.
HY: Design and critical revision of the manuscript.
All the authors have approved the final version of the manuscript to be published.

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